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Hanafusa et al.

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(54) **HEAT EXCHANGE SYSTEM, AND FIN STRUCTURE OF HEAT EXCHANGER**

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CPC F28D 9/0062; F28D 1/024; F28F 27/00; F28F 3/025; F28F 2215/10; F28F 2250/08
See application file for complete search history.

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(57) **ABSTRACT**

A heat exchanger (**1**) includes a heat exchanger (**1**) including a separate plate (**10**) and a first flow path (**11**) which is divided by a plurality of fin portions (**13***a*) and through which air flows, a fan (**2**), and a control unit (**3**) that performs control for switching between a first mode where heat exchange is performed by forcing air to flow in and a second mode where heat exchange is performed by natural convection, the plurality of fin portions (**13***a*) are disposed in parallel at predetermined intervals (p**1**), and are formed to have an undulating shape from one end (**11***b*) toward the other end (**11***c*) of the first flow path (**11**) in a width direction of the first flow path (**11**), and the first flow path (**11**) is configured to be used in both the first mode and the second mode.

5 Claims, 12 Drawing Sheets

FIRST EMBODIMENT

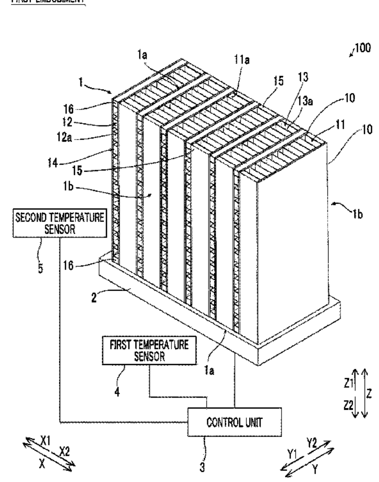

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FIG. 1

FIRST EMBODIMENT

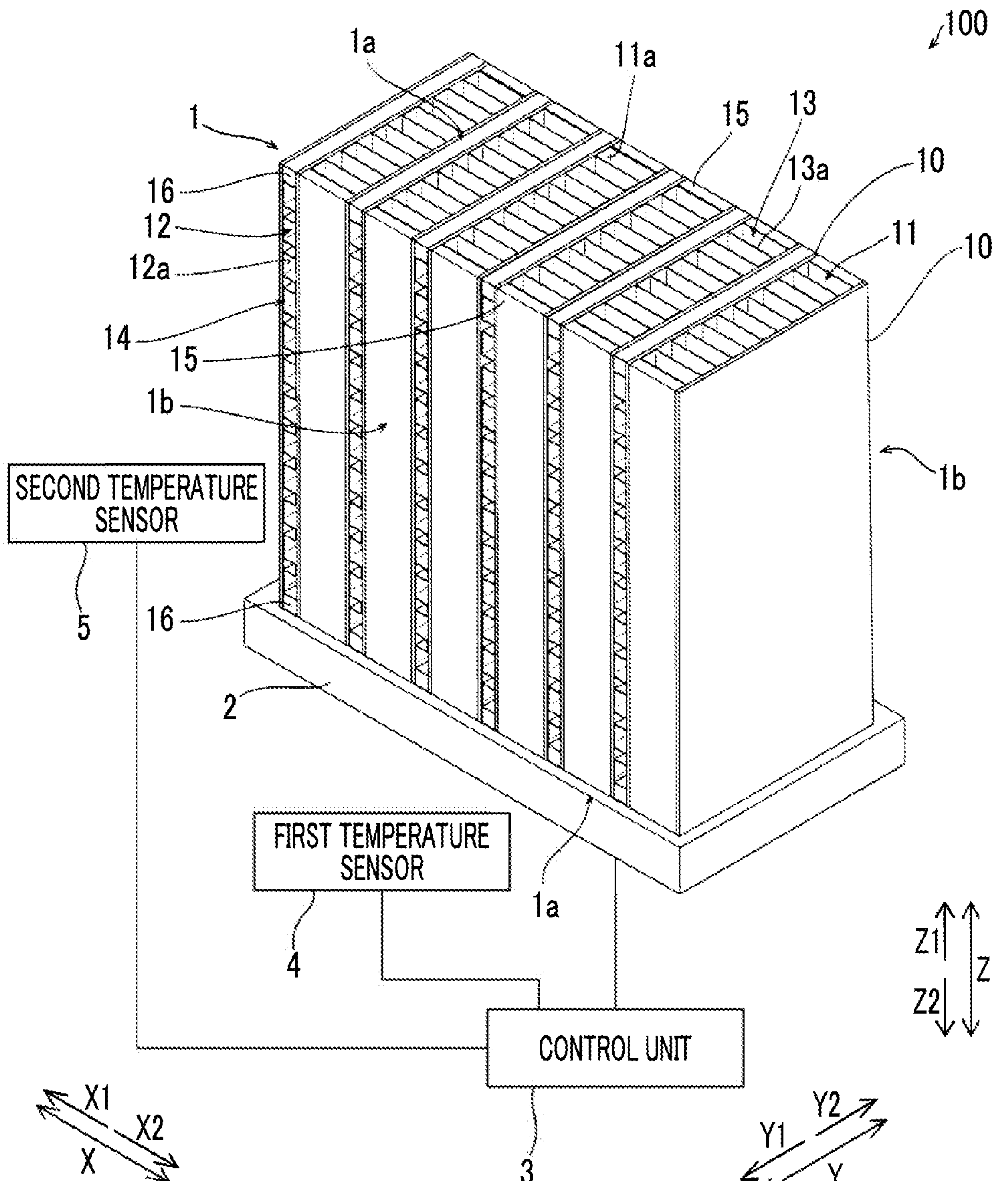

FIG. 2

FIRST EMBODIMENT

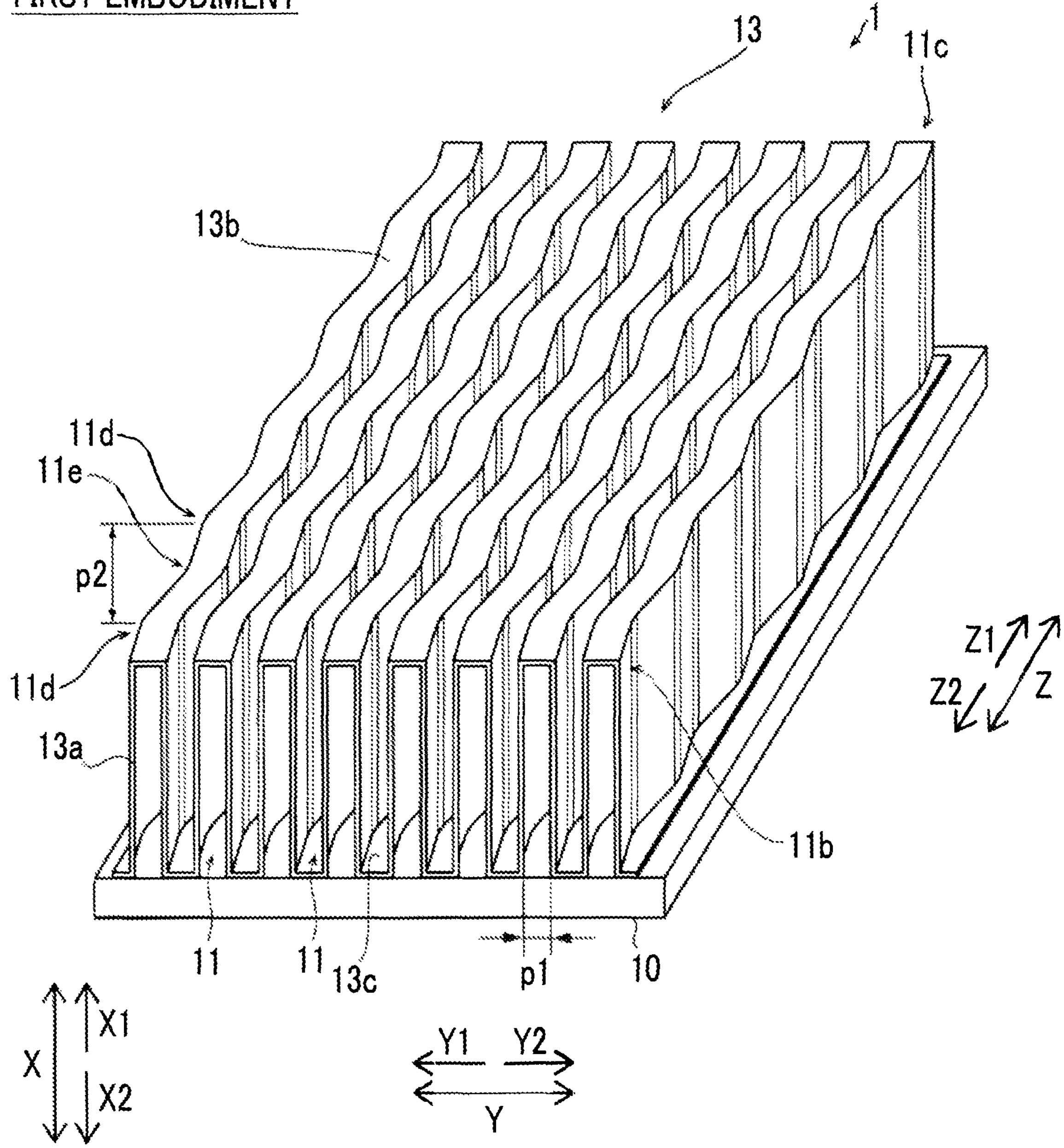

FIG. 3

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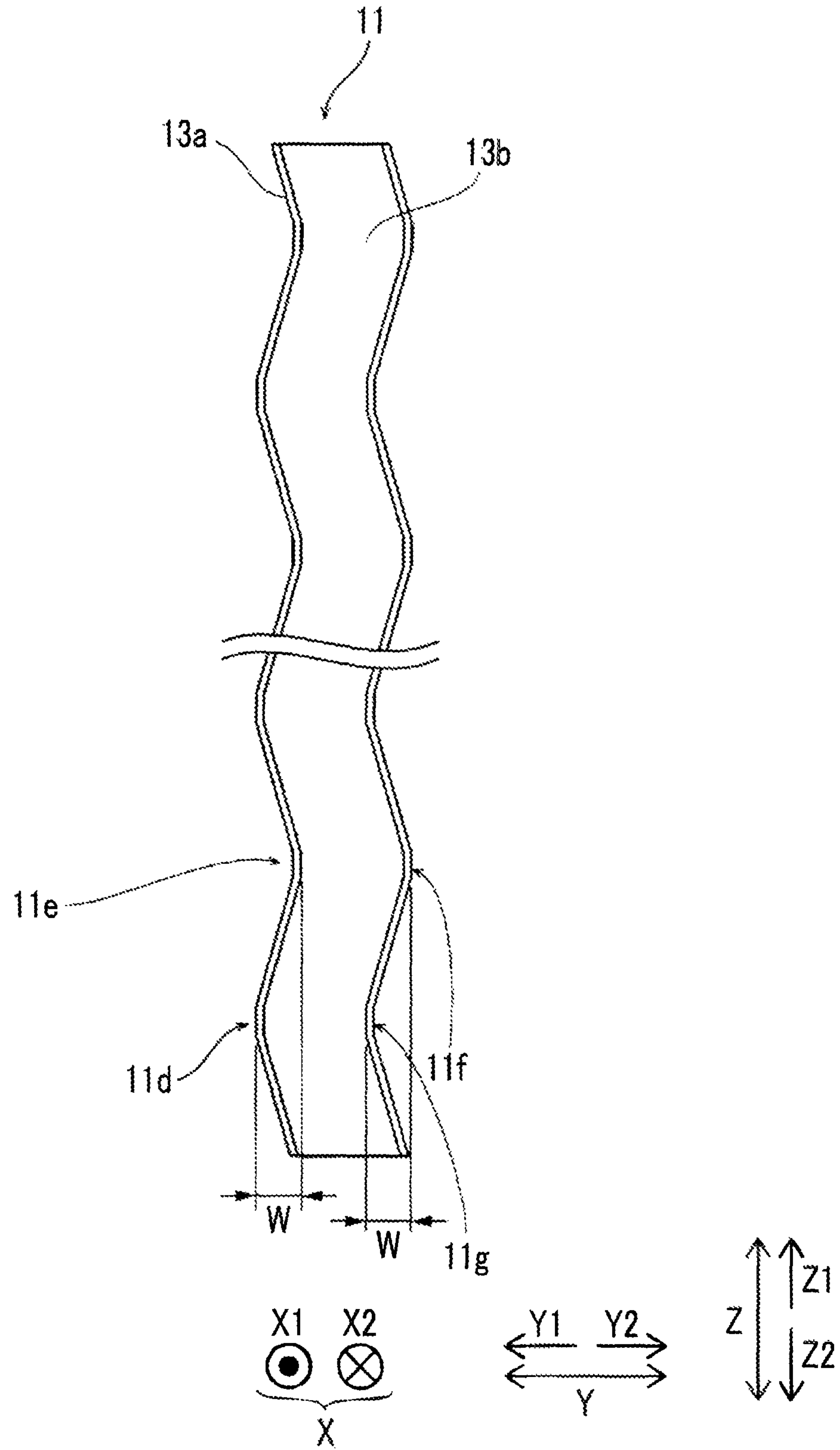


FIG. 4

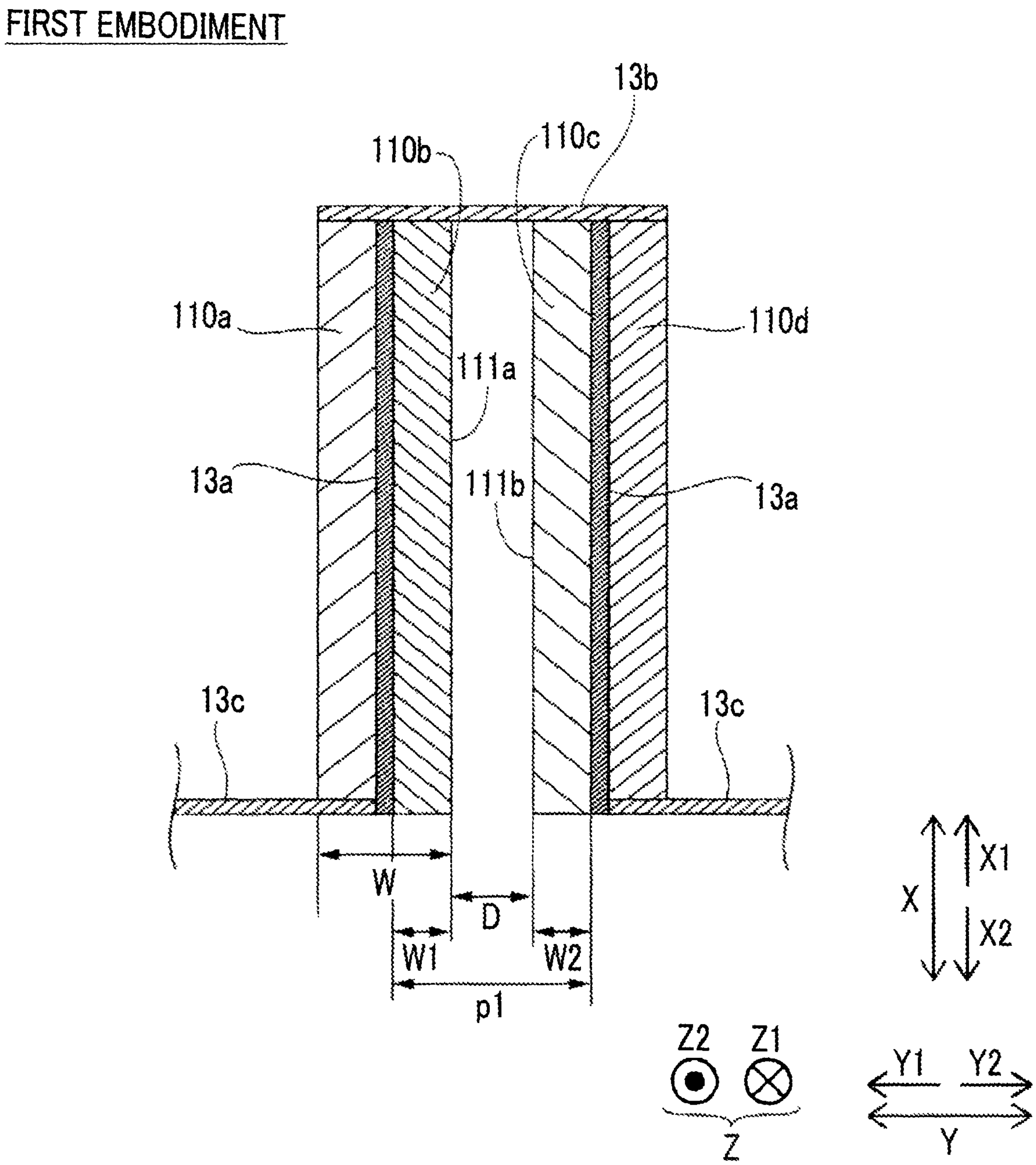

FIRST EMBODIMENT
13b
110b
110c
110a
110d
111a
13a
111b
13a
13c
13c
W
D
W1
W2
p1
X
X1
X2
Z2
Z1
Z
Y1
Y2
Y

FIG. 5

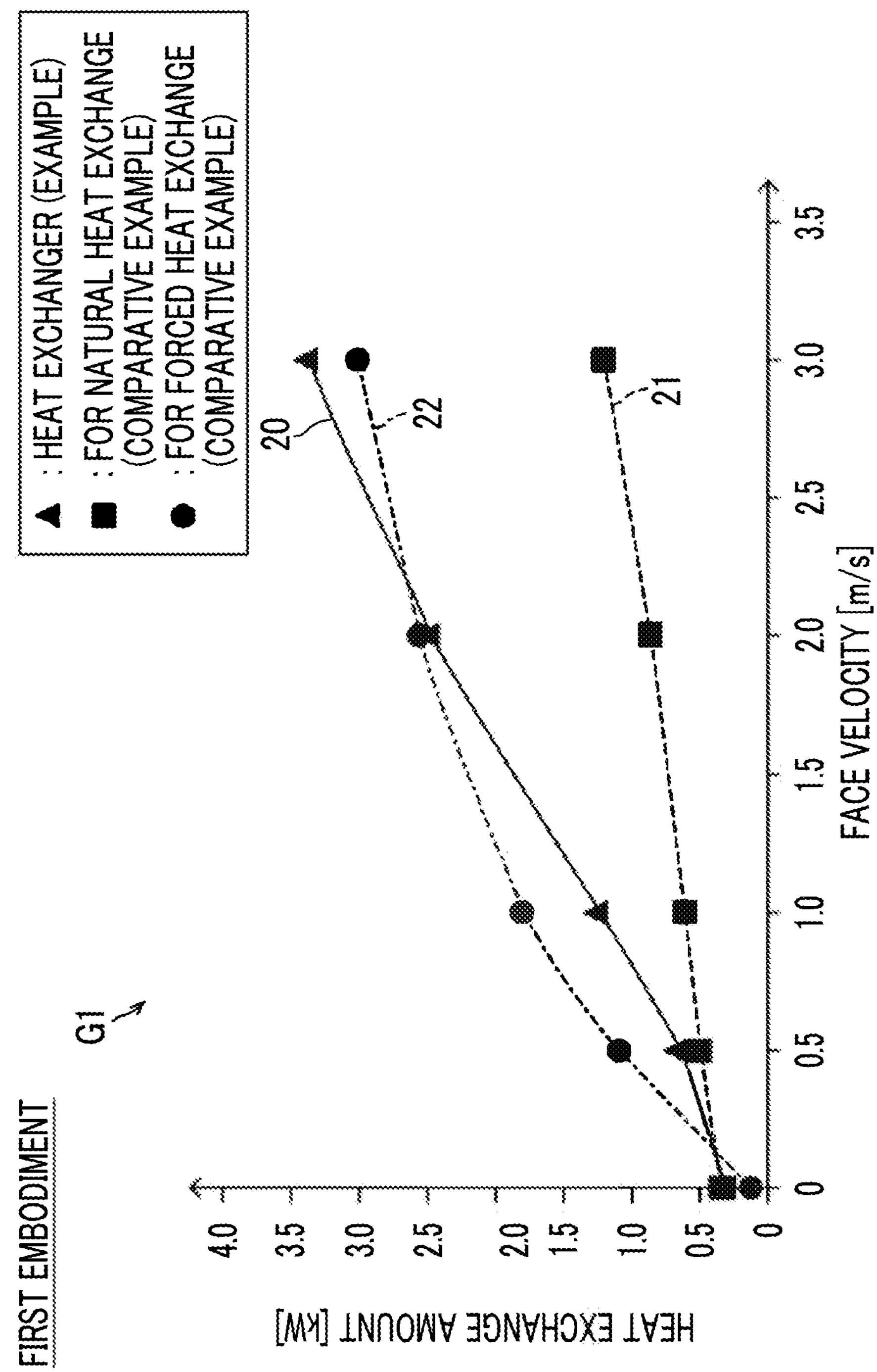
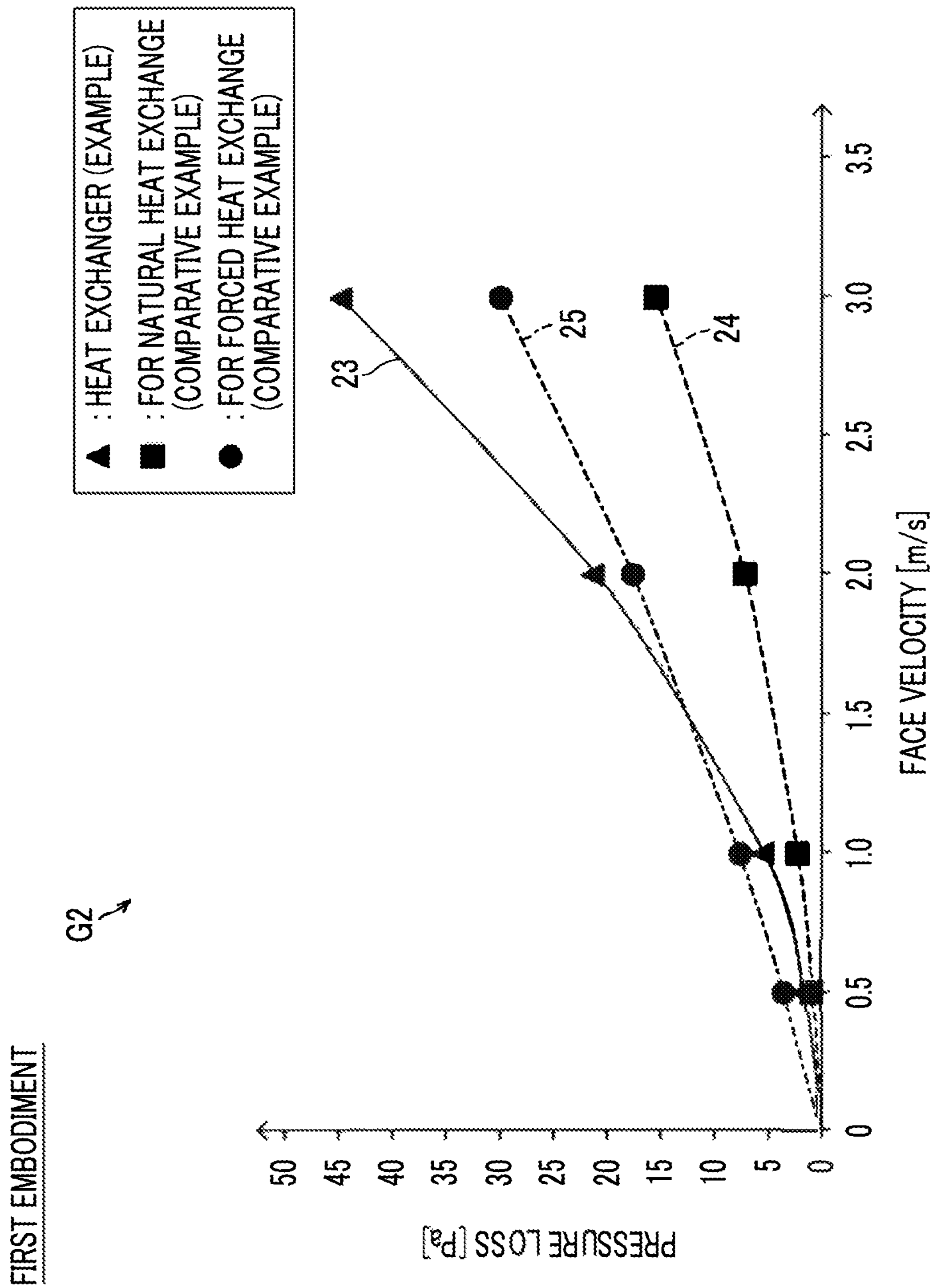

FIRST EMBODIMENT
G1
▲ : HEAT EXCHANGER (EXAMPLE)
■ : FOR NATURAL HEAT EXCHANGE (COMPARATIVE EXAMPLE)
● : FOR FORCED HEAT EXCHANGE (COMPARATIVE EXAMPLE)
20
22
21
HEAT EXCHANGE AMOUNT [kW]
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.3
0
FACE VELOCITY [m/s]
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5

FIG. 6



FIRST EMBODIMENT
G2
: HEAT EXCHANGER (EXAMPLE)
: FOR NATURAL HEAT EXCHANGE (COMPARATIVE EXAMPLE)
: FOR FORCED HEAT EXCHANGE (COMPARATIVE EXAMPLE)
23
24
25
PRESSURE LOSS [Pa]
50
45
40
35
30
25
20
15
10
5
0
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
FACE VELOCITY [m/s]

FIG. 7

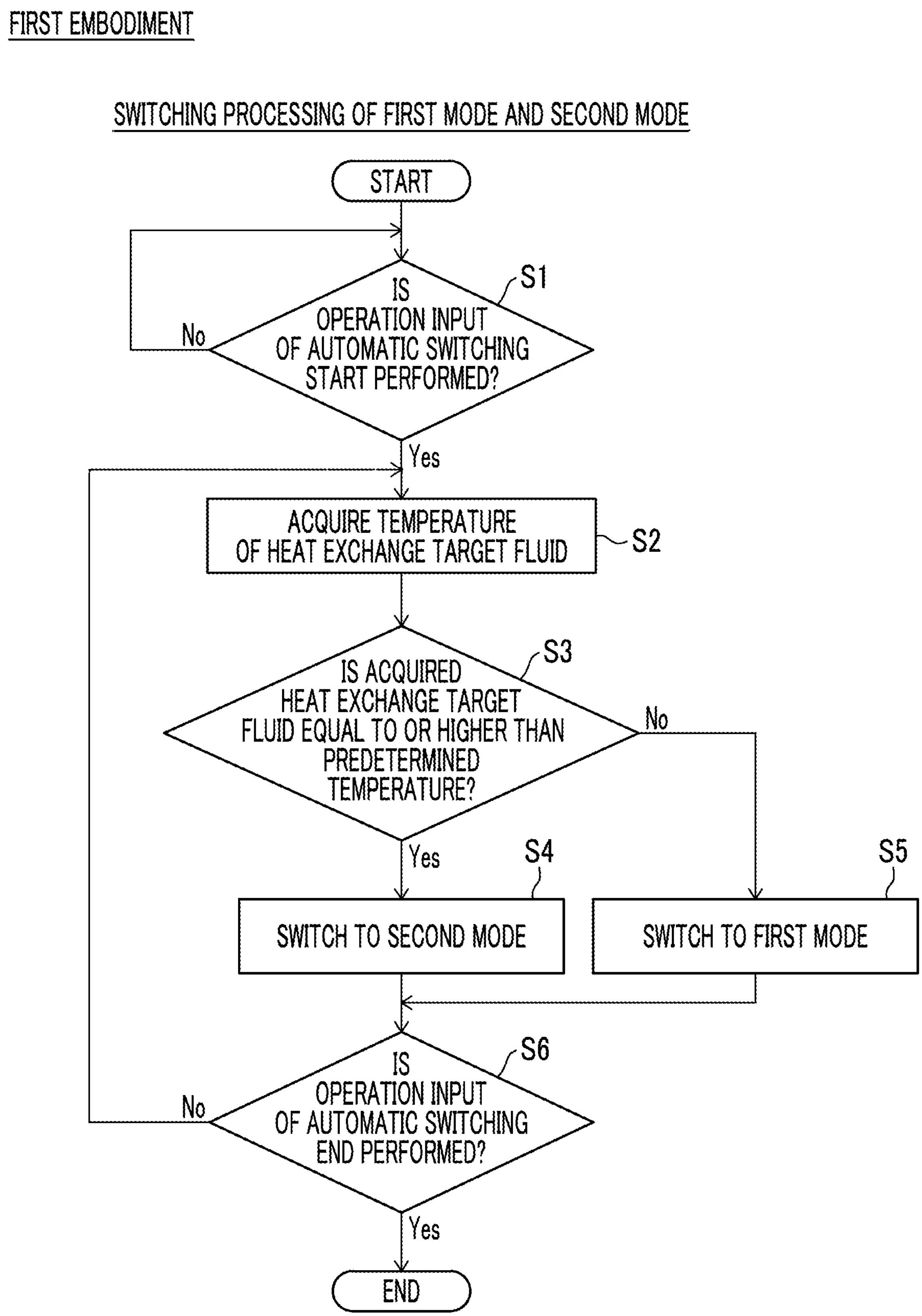

FIRST EMBODIMENT
SWITCHING PROCESSING OF FIRST MODE AND SECOND MODE
START
IS OPERATION INPUT OF AUTOMATIC SWITCHING START PERFORMED?
S1
No
Yes
ACQUIRE TEMPERATURE OF HEAT EXCHANGE TARGET FLUID
S2
IS ACQUIRED HEAT EXCHANGE TARGET FLUID EQUAL TO OR HIGHER THAN PREDETERMINED TEMPERATURE?
S3
No
Yes
S4
S5
SWITCH TO SECOND MODE
SWITCH TO FIRST MODE
IS OPERATION INPUT OF AUTOMATIC SWITCHING END PERFORMED?
S6
No
Yes
END

FIG. 8

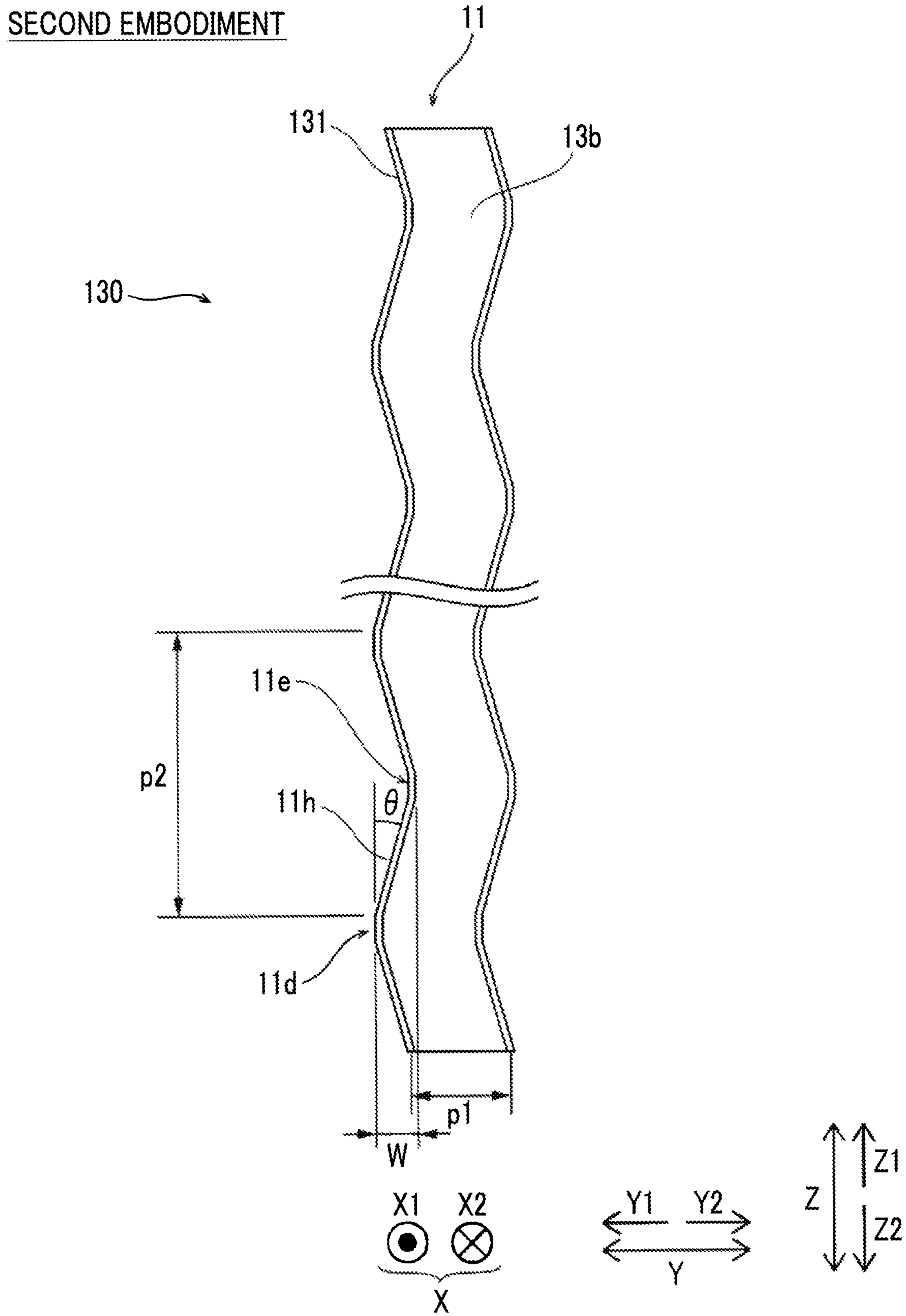

SECOND EMBODIMENT
11
131
13b
130
11e
p2
11h
θ
11d
p1
W
X1
X2
X
Y1
Y2
Y
Z
Z1
Z2

FIG. 9

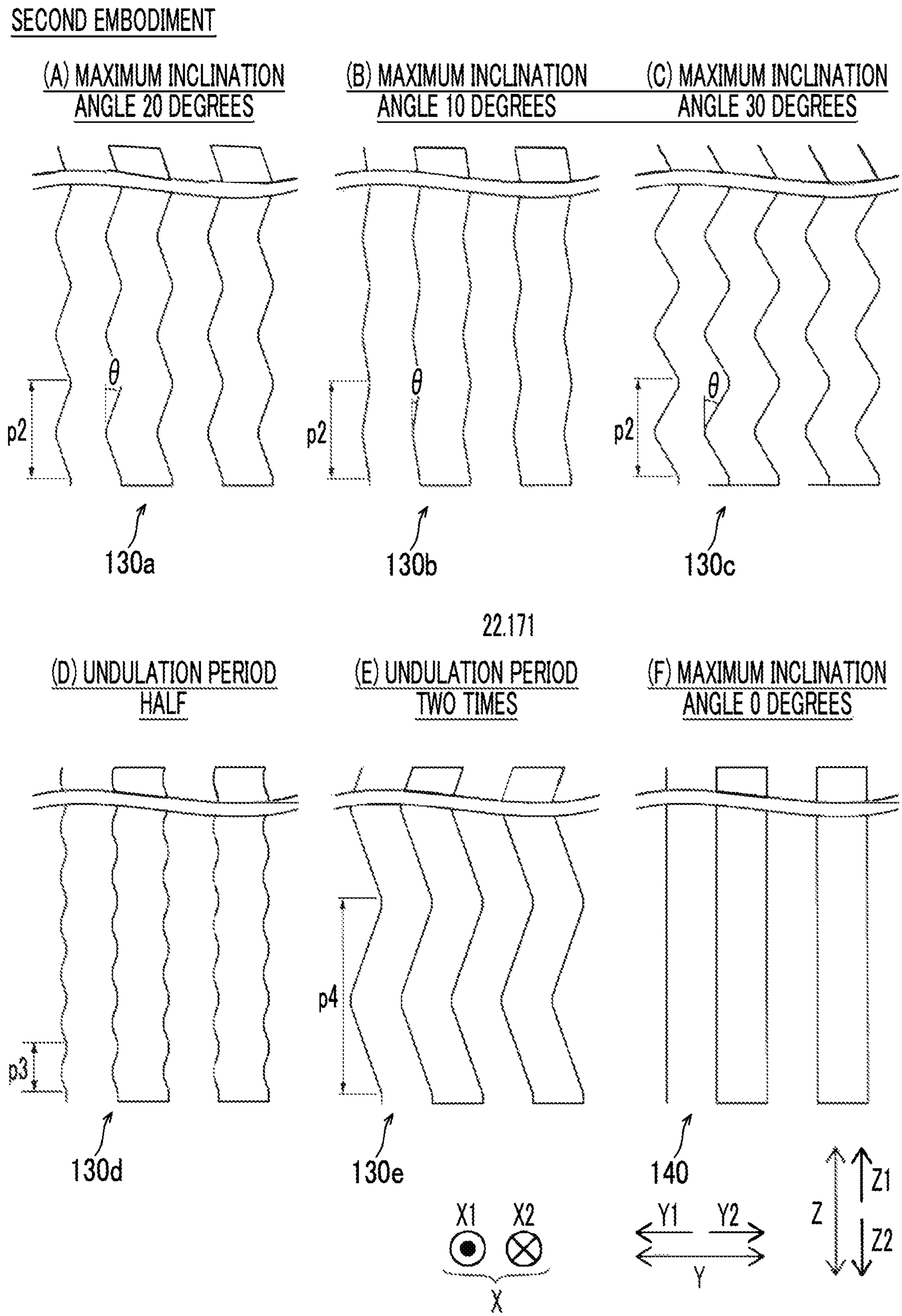

SECOND EMBODIMENT
(A) MAXIMUM INCLINATION ANGLE 20 DEGREES
(B) MAXIMUM INCLINATION ANGLE 10 DEGREES
(C) MAXIMUM INCLINATION ANGLE 30 DEGREES
p2
θ
130a
130b
130c
22.171
(D) UNDULATION PERIOD HALF
(E) UNDULATION PERIOD TWO TIMES
(F) MAXIMUM INCLINATION ANGLE 0 DEGREES
p3
p4
130d
130e
140
X1
X2
X
Y1
Y2
Y
Z
Z1
Z2

FIG. 10

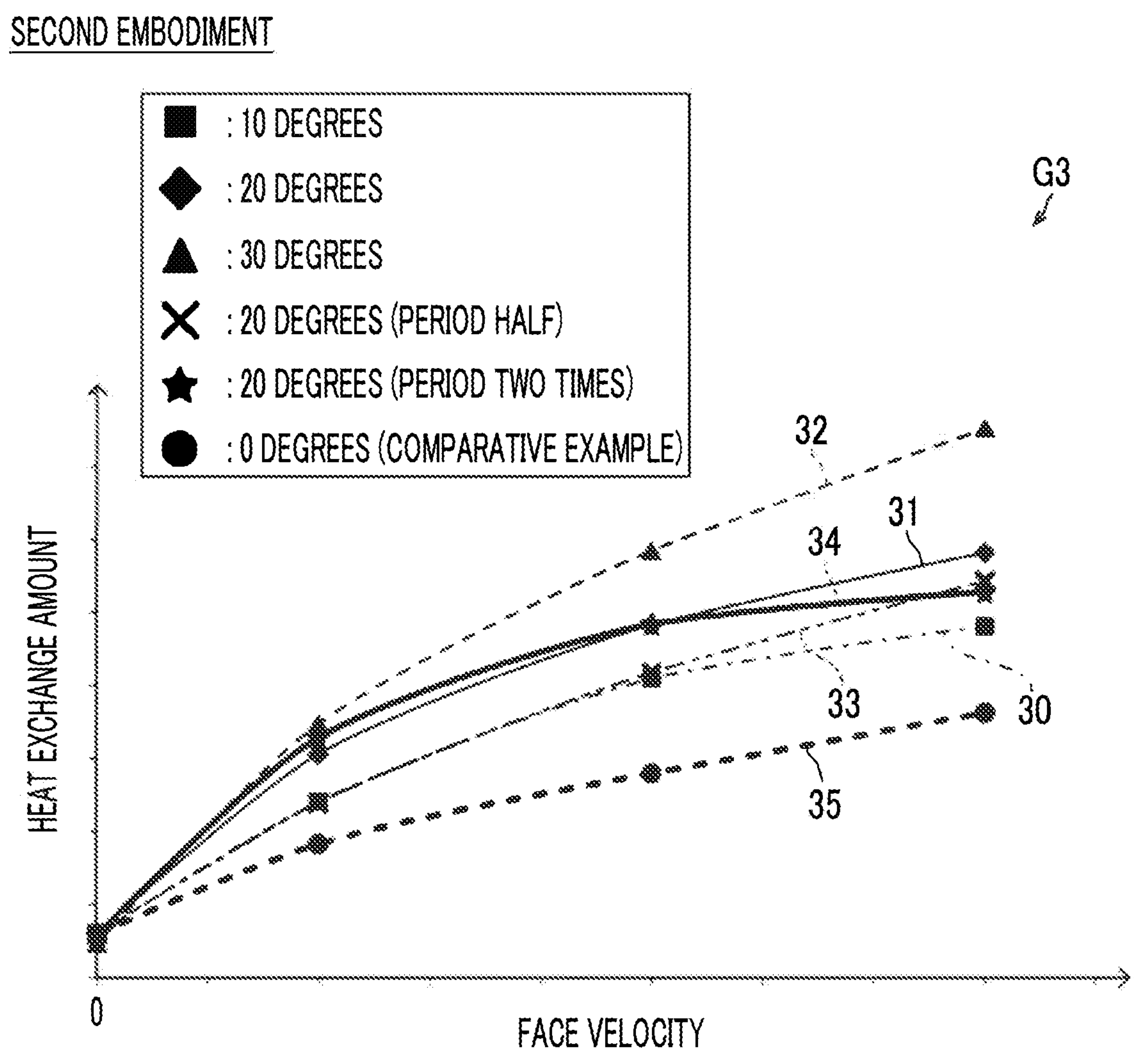

SECOND EMBODIMENT
: 10 DEGREES
: 20 DEGREES
: 30 DEGREES
: 20 DEGREES (PERIOD HALF)
: 20 DEGREES (PERIOD TWO TIMES)
: 0 DEGREES (COMPARATIVE EXAMPLE)
G3
32
31
34
33
30
35
HEAT EXCHANGE AMOUNT
0
FACE VELOCITY

FIG. 11

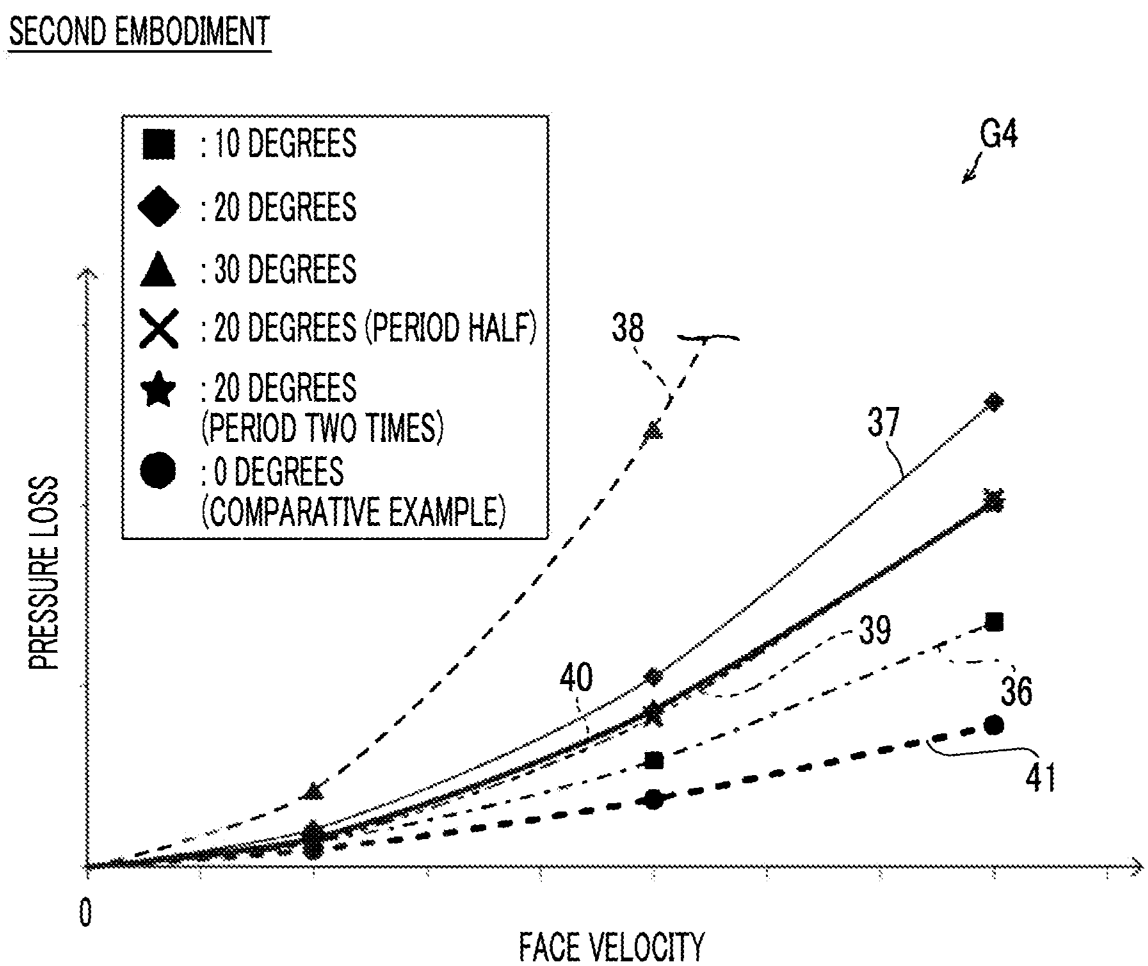
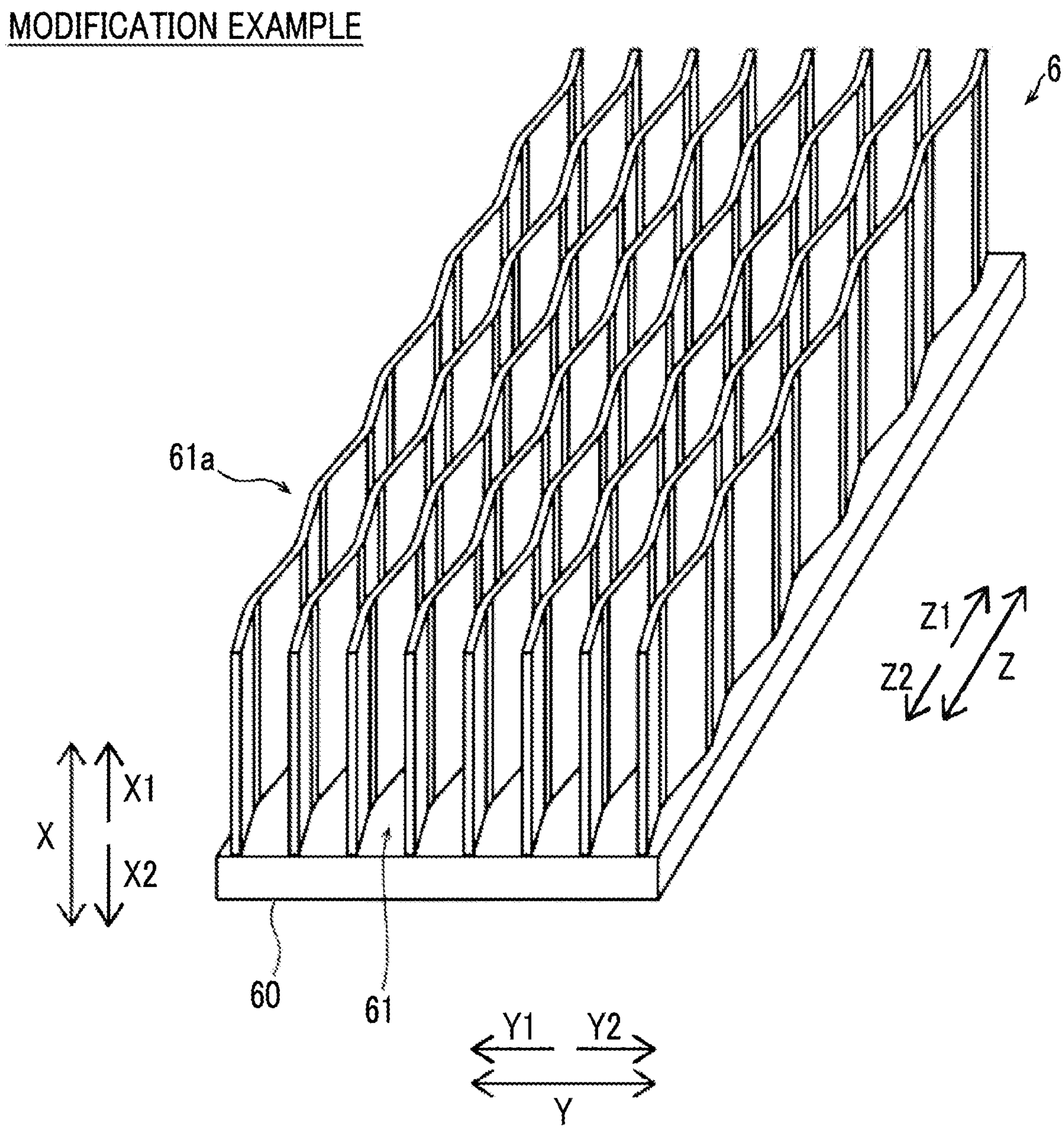

SECOND EMBODIMENT
G4
: 10 DEGREES
: 20 DEGREES
: 30 DEGREES
: 20 DEGREES (PERIOD HALF)
: 20 DEGREES
(PERIOD TWO TIMES)
: 0 DEGREES
(COMPARATIVE EXAMPLE)
38
37
39
40
36
41
PRESSURE LOSS
0
FACE VELOCITY

FIG. 12



HEAT EXCHANGE SYSTEM, AND FIN STRUCTURE OF HEAT EXCHANGER

TECHNICAL FIELD

The present invention relates to a heat exchange system and a fin structure of a heat exchanger, and in particular, to a heat exchange system and a fin structure of a heat exchanger that perform heat exchange by natural convection and heat exchange by forcing air to flow in.

BACKGROUND ART

In the related art, a heat exchange system and a fin structure of a heat exchanger that perform heat exchange by natural convection and heat exchange by forcing air to flow in are known. Such a heat exchange system is disclosed in, for example, JP-S61-197416U.

JP-S61-197416U discloses a heat exchanger including a plurality of conduits, a connecting pipe having a U shape that connects the conduits, a plurality of fins, and a motor fan. The plurality of conduits are disposed in parallel and have end portions connected by the connecting pipe having a U shape. The plurality of fins are disposed to form a forced convection part with a narrowed pitch (disposition interval) and natural convection parts. The forced convection part is provided in a central portion of the plurality of fins, and the natural convection parts are provided on right and left sides of the forced convection part. In the configuration disclosed in JP-S61-197416U, the motor fan is provided in the forced convection part. The heat exchanger disclosed in JP-S61-197416U is configured to switch between natural convection and forced convection as needed to perform cooling (heat exchange).

CITATION LIST

Patent Literature

[PTL 1] JP-S61-197416U

SUMMARY OF INVENTION

Technical Problem

Here, since the forced convection part disclosed in JP-S61-197416U has the disposition interval of the fins narrower (smaller) than in the natural convection parts, the forced convection part increases in flow path resistance. In such a configuration, though not clearly stated in JP-S61-197416U, the forced convection part cannot be used in heat exchange by natural convection. For this reason, in the configuration disclosed in JP-S61-197416U, heat exchange by natural convection is performed only in the natural convection parts, and heat exchange by forcing air to flow in is performed only in the forced convection part.

Note that, in a case where the natural convection parts and the forced convection part are formed using a plurality of fins, the plurality of fins are divided into fins used only in heat exchange by natural convection and fins used only in heat exchange by forcing air to flow in. That is, since a part of the plurality of fins is used only in heat exchange by natural convection, and the remaining fins are used only in heat exchange by forcing air to flow in, the number of fins used in heat exchange by natural convection and the number of fins used in heat exchange by forcing air to flow in decrease compared to a configuration in which heat exchange is performed using all fins. For this reason, in a case of switching between performing heat exchange by natural convection and heat exchange by forcing air to flow in, there is a problem in that heat exchange efficiency of respective heat exchange is degraded.

The invention has been accomplished to solve the problem described above, and an object of the invention is to provide a heat exchange system and a fin structure of a heat exchanger capable of, in a case of switching between performing heat exchange by natural convection and heat exchange by forcing air to flow in, suppressing degradation of heat exchange efficiency of respective heat exchange.

Solution to Problem

To achieve the above-described object, the present inventors have conducted intensive studies and have found that a plurality of fin portions in a first flow path of a heat exchanger undulate to be usable in both heat exchange by natural convection and heat exchange by forcing air to flow into the first flow path. Based on the knowledge, a heat exchange system according to a first invention includes a heat exchanger including a base portion that comes into contact with a heat exchange target, and a first flow path which is divided by a plurality of fin portions extending upward from the base portion and through which air flows, a fan that makes air flow into the first flow path, and a control unit that performs control for switching between a first mode where heat exchange of the heat exchange target is performed by forcing air to flow into the first flow path with the fan and a second mode where the heat exchange of the heat exchange target is performed by natural convection, in which the plurality of fin portions are disposed in parallel at predetermined intervals in a width direction of the first flow path, the plurality of fin portions are formed to have an undulating shape from one end toward the other end of the first flow path in the width direction of the first flow path, and the first flow path is configured to be used in both the first mode and the second mode.

In the heat exchanger according to the invention, as described above, the plurality of fin portions are disposed in parallel at the predetermined intervals in the width direction of the first flow path through which air flows, and are formed to have the undulating shape from one end toward the other end of the first flow path in the width direction of the first flow path, and the first flow path is configured to be used in both the first mode where the heat exchange is performed by forcing air to flow in and the second mode where the heat exchange is performed by the natural convection. With this, since the first flow path is used in both the first mode and the second mode, it is possible to suppress a decrease in the number of fin portions used in each heat exchange mode, compared to a configuration in which fin portions including both fin portions used only in the first mode and fin portions used only in the second mode are provided in the first flow path. Since the plurality of fin portions have the undulating shape in the width direction of the first flow path, it is possible to promote heat transfer with turbulence of flown-in air, compared to a configuration in which the plurality of fin portions do not have an undulating shape. It is possible to increase a heat transfer area without narrowing the disposition interval of the fin portions. As a result, in a case of switching between performing heat exchange by natural convection and heat exchange by forcing air to flow in, it is possible to suppress degradation of heat exchange efficiency of respective heat exchange.

In this case, preferably, the plurality of fin portions are provided continuously from the one end to the other end of the first flow path and undulate periodically such that the other end of the first flow path is visible as viewed from the one end of the first flow path. With this configuration, a through flow path is formed in the first flow path. Accordingly, it is possible to suppress an increase in pressure loss of air flowing in the first flow path, compared to a configuration in which a through flow path is not formed in the first flow path with the plurality of fin portions. As a result, even in a case where the plurality of fin portions have the undulating shape, it is possible to secure heat exchange efficiency in the second mode where heat exchange is performed by natural convection.

In the above-described configuration in which the plurality of fin portions are provided continuously from the one end to the other end of the first flow path and undulate periodically such that the other end of the first flow path is visible as viewed from the one end of the first flow path, preferably, the plurality of fin portions undulate such that an undulating pattern of the same waveform is repeated at a fixed undulation width in the width direction of the first flow path, and the undulation width is at least a size less than a half of a disposition interval of the plurality of fin portions. With this configuration, since the plurality of fin portions undulate such that the undulating pattern of the same waveform is repeated at the fixed undulation width in the width direction of the first flow path, it is possible to simplify the structure (shape) of the plurality of fin portions, compared to a configuration in which the undulation width and/or the undulating pattern of the plurality of fin portions is different halfway. Since the undulation width of the plurality of fin portions is at least the size less than a half of the disposition interval of the plurality of fin portions, it is possible to make a configuration in which the other end of the first flow path is visible as viewed from the one end of the first flow path, and to secure heat exchange efficiency in the second mode. As a result, it is possible to achieve both the simplification of the structure (shape) of the plurality of fin portions and securing of heat exchange efficiency in the second mode.

In the above-described configuration in which the plurality of fin portions are provided continuously from the one end to the other end of the first flow path and undulate periodically such that the other end of the first flow path is visible as viewed from the one end of the first flow path, preferably, the plurality of fin portions undulate such that an undulating pattern of the same waveform is repeated at a fixed undulation width in the width direction of the first flow path, the undulating pattern includes a crest portion that protrudes to one side, a trough portion that protrudes to the other side, and a connecting portion that connects the crest portion and the trough portion, in the width direction of the first flow path, and a maximum inclination angle of the connecting portion with respect to a direction from one end side to the other end side of the first flow path is within an angle range of equal to or greater than 10 degrees and equal to or less than 30 degrees.

Here, in a case where a period of undulation of the first flow path is fixed, as the maximum inclination angle of the connecting portion is greater, the effect of turbulence in the first flow path is increased, and it is possible to further increase a heat transfer area. As the heat transfer area of the first flow path is increased, it is possible to improve heat exchange performance by the first mode where air is forced to flow in. Note that, in a case where the maximum inclination angle of the connecting portion is large, since a pressure loss in the first flow path increases, heat exchange efficiency in the second mode where heat exchange is performed by natural convection of air is degraded. In a case where the period of undulation of the first flow path is fixed, as the maximum inclination angle of the connecting portion is smaller, since the effect of turbulence of the first flow path is decreased, and the heat transfer area is decreased, heat exchange performance by the first mode is degraded. Note that, in a case where the maximum inclination angle of the connecting portion is small, since the pressure loss of the first flow path decreases, heat exchange efficiency in the second mode is improved. Accordingly, the present inventors have conducted studies and have confirmed that, in a case where the maximum inclination angle of the connecting portion falls within an angle range of equal to or greater than 10 degrees and equal to or less than 30 degrees, it is possible to secure high performance in any of the heat exchange in the first mode and the heat exchange in the second mode.

In the heat exchange system according to the first invention described above, preferably, a disposition interval of the plurality of fin portions is within a range of equal to or greater than 5 mm and equal to or less than 10 mm. With this configuration, it is possible to dispose the plurality of fin portions at intervals suitable for the second mode where heat exchange is performed by natural convection. In a case where the disposition interval of the plurality of fin portions is set within this range, while high performance is obtained in the second mode where heat exchange is performed by natural convection of air, the disposition interval is large for the first mode where heat exchange is performed by forcing air to flow in. That is, in a case where the plurality of fin portions are disposed at the disposition intervals within the range of equal to or greater than 5 mm and equal to or less than 10 mm, heat exchange performance by the first mode is degraded. Accordingly, the present inventors have conducted studies and have confirmed that the plurality of fin portions have the undulating shape, such that it is also possible to secure high performance in heat exchange by the first mode even in a case where the plurality of fin portions are disposed at the disposition intervals within the range of equal to or greater than 5 mm and equal to or less than 10 mm.

In the heat exchanger according to the invention described above, preferably, the plurality of fin portions are disposed at equal intervals over a whole width in the width direction of the first flow path. With this configuration, since the plurality of fin portions are disposed at the equal intervals over the whole width in the width direction of the first flow path, it is possible to perform heat exchange by the first mode and heat exchange by the second mode using the whole first flow path, unlike a configuration in which a part where heat exchange is performed by the first mode and a part where heat exchange is performed by the second mode are formed by changing the disposition interval of the plurality of fin portions. As a result, it is possible to suppress degradation of heat exchange efficiency of each heat exchange mode.

In the heat exchange system according to the first invention described above, preferably, the control unit is configured to switch between the first mode and the second mode based on a temperature of the heat exchange target. With this configuration, since the first mode and the second mode are switched based on the temperature of the heat exchange target, it is possible to suppress an increase in power consumption, for example, compared to a configuration in which heat exchange is constantly by the first mode. It is possible to efficiently perform the heat exchange of the heat exchange target, for example, compared to a configuration in which heat exchange is constantly performed by the second mode. As a result, it is possible to efficiently perform the heat exchange of the heat exchange target while suppressing an increase in power consumption.

In the heat exchange system according to the first invention described above, preferably, the heat exchange target includes a heat exchange target fluid, and the heat exchanger further includes a second flow path through which the heat exchange target fluid flows in a state of being in contact with the base portion where a plurality of fin portions are provided. With this configuration, it is possible to easily bring the base portion in which the plurality of fin portions are provided, and the heat exchange target fluid into contact with each other by making the heat exchange target fluid flow into the second flow path, and to easily perform the heat exchange of the heat exchange target fluid.

A fin structure of a heat exchanger according to a second invention includes a base portion that comes into contact with a heat exchange target, and a plurality of fin portions provided to extend upward from the base portion, in which the plurality of fin portions form a first flow path through which air flows, have an undulating shape from one end toward the other end of the formed first flow path in a width direction of the first flow path, are disposed at equal intervals over a whole width in the width direction of the first flow path, are provided continuously from the one end to the other end of the first flow path, and, undulate periodically such that the other end of the first flow path is visible as viewed from the one end of the first flow path, and in performing heat exchange of the heat exchange target, the first flow path is configured to be used in both forced heat exchange where the heat exchange of the heat exchange target is performed by forcing air to flow into the first flow path and natural heat exchange where the heat exchange of the heat exchange target is performed by natural convection.

In the fin structure of a heat exchanger according to the second invention, as described above, the plurality of fin portions are disposed in parallel at the predetermined intervals in the width direction of the first flow path, and have the undulating shape from one end toward the other end of the first flow path in the width direction of the first flow path. With this, like the heat exchange system according to the first invention described above, in a case of switching between performing heat exchange by natural convection and heat exchange by forcing air to flow in, it is possible to provide the fin structure of the heat exchanger capable of suppressing degradation of heat exchange efficiency of respective heat exchange. In the fin structure of the heat exchanger according to the second invention, the plurality of fin portions are disposed at the equal intervals over the whole width in the width direction of the first flow path. With this, since the plurality of fin portions are disposed at the equal intervals over the whole width in the width direction of the first flow path, it is possible to perform heat exchange by the first mode and heat exchange by the second mode using the whole first flow path, unlike a configuration in which a part where heat exchange is performed by the first mode and a part where heat exchange is performed by the second mode are formed by changing the disposition interval of the plurality of fin portions halfway of the first flow path. As a result, it is possible to suppress degradation of heat exchange efficiency of each heat exchange mode.

In the fin structure of the heat exchanger according to the second invention, the plurality of fin portions are provided continuously from one end to the other end of the first flow path, and undulate periodically such that the other end of the first flow path is visible as viewed from one end of the first flow path. With this, a through flow path is formed in the first flow path. Accordingly, it is possible to suppress an increase in pressure loss of air flowing in the first flow path, compared to a configuration in which a through flow path is not formed in the first flow path with the plurality of fin portions. As a result, even in a case where the plurality of fin portions have the undulating shape, it is possible to secure heat exchange efficiency in the second mode where heat exchange is performed by natural convection.

Advantageous Effects of Invention

According to the invention, as described above, in a case of switching between performing heat exchange by natural convection and heat exchange by forcing air to flow in, it is possible to suppress degradation of heat exchange efficiency of respective heat exchange.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a perspective view showing a heat exchange system according to a first embodiment.

FIG. **2** is a perspective view showing a base portion and a plurality of fin portions of a heat exchanger according to the first embodiment.

FIG. **3** is a schematic view as a first flow path according to the first embodiment is viewed from an X1 direction.

FIG. **4** is a schematic view as the first flow path according to the first embodiment is viewed from a Z1 direction.

FIG. **5** is a simulation result showing change in heat exchange amount in changing a front face wind velocity using the heat exchanger according to the first embodiment and a heat exchanger according to a comparative example.

FIG. **6** is a simulation result showing change in pressure loss in changing the front face wind velocity using the heat exchanger according to the first embodiment and the heat exchanger according to the comparative example.

FIG. **7** is a flowchart illustrating processing in which the heat exchange system according to the first embodiment switches between a first mode and a second mode.

FIG. **8** is a schematic view illustrating a maximum inclination angle of a connecting portion according to a second embodiment.

FIG. **9** is a schematic view (A) to a schematic view (F) illustrating a heat exchanger used in a simulation according to the second embodiment and a heat exchanger of a comparative example.

FIG. **10** is a simulation result showing change in heat exchange amount in changing a front face wind velocity in the heat exchanger according to the second embodiment in which an angle of a connecting portion of a first flow path and a period are made different.

FIG. **11** is a simulation result showing change in pressure loss in changing the front face wind velocity in the heat exchanger according to the second embodiment in which the angle of the connecting portion of the first flow path and the period are made different.

FIG. **12** is a perspective view showing a base portion and a plurality of fin portions of a heat exchanger according to a modification example.

DESCRIPTION OF EMBODIMENTS

Hereinafter, embodiments of the invention will be described based on the drawings.

First Embodiment

(Configuration of Heat Exchanger)

First, an overall configuration of a heat exchange system **100** according to the present embodiment will be described with reference to FIGS. **1** to **4**.

(Overall Configuration)

As shown in FIG. **1**, a heat exchange system **100** includes a heat exchanger **1**, a fan **2**, a control unit **3**, a first temperature sensor **4**, and a second temperature sensor **5**. In the present specification, an up-down direction is represented as a Z direction, an up direction is represented as a Z1 direction, and a down direction is represented as a Z2 direction. Two directions perpendicular to each other within a plane perpendicular to the Z direction are represented as an X direction and a Y direction. In the X direction, one side is represented as an X1 direction, and the other side is represented as an X2 direction. In the Y direction, one side is represented as a Y1 direction, and the other side is represented as a Y2 direction.

The heat exchanger **1** has an opening that is an inlet or an outlet of a fluid and is configured to make the fluid flow to perform heat exchange. FIG. **1** shows an example where the heat exchanger **1** is a plate fin type heat exchanger. The plate fin type heat exchanger **1** has a rectangular parallelepiped shape including a surface (side surface) where the opening is formed. The heat exchanger **1** has a flow path for making the fluid flow inside and is configured to perform heat exchange in a process of making the fluid flow. The heat exchange that is performed by the heat exchanger **1** includes cooling and heating. In the present embodiment, a case where the heat exchanger **1** performs cooling of a heat exchange target will be described.

The heat exchanger **1** has a structure in which separate plates **10**, first corrugated fins **13**, and second corrugated fins **14** are laminated. First side bars **15** are disposed on in outer peripheral portions of each first corrugated fin **13**. Second side bars **16** are disposed in outer peripheral portions of each second corrugated fin **14**. The first corrugated fins **13**, the second corrugated fins **14**, the separate plates **10**, the first side bars **15**, and the second side bars **16** are bonded by brazing, whereby the heat exchanger **1** is configured. Each separate plate **10** is an example of a "base portion" in the claims.

A first flow path **11** is divided by the separate plate **10**, the first side bar **15**, and the separate plate **10**, and is configured with each layer where the first corrugated fin **13** is disposed inside. Air as the fluid flows in the first flow path **11**. In the present embodiment, the first flow path **11** is formed to extend in the up-down direction (Z direction). In the example shown in FIG. **1**, the Y direction is a width direction of the first flow path **11**. The X direction is a height direction of the first flow path **11**.

A second flow path **12** is divided by the separate plate **10**, the second side bar **16**, and the separate plate **10**, and is configured with each layer where the second corrugated fin **14** is disposed inside. A heat exchange target fluid flows in the second flow path **12** in a state of being in contact with the separate plate **10**.

In the present embodiment, the heat exchanger **1** performs heat exchange between air and the heat exchange target fluid flowing in the first flow path **11** and the second flow path **12**, respectively. In the example shown in FIG. **1**, air flows into the first flow path **11** from a Z2 direction side and flows out from a Z1 direction side. The heat exchange target fluid flows into the second flow path **12** from a Y1 direction side and flows out from a Y2 direction side.

The separate plate **10** has a rectangular shape. The separate plate **10** is configured to come into contact with the heat exchange target. The heat exchange target includes the heat exchange target fluid. The heat exchange target fluid includes, for example, oil or a refrigerant.

The heat exchanger **1** has a structure in which the first flow path **11** and the second flow path **12** are alternately laminated such that the first flow path **11** and the second flow path **12** are perpendicular to each other. The first flow path **11** and the second flow path **12** are laminated in the X direction.

In the example of FIG. **1**, the heat exchanger **1** includes surfaces **1***a* where an opening **11***a* of the first flow path **11** is formed and surfaces **1***b* where an opening **12***a* of the second flow path **12** is formed. The opening **11***a* of the first flow path **11** is formed in both surfaces **1***a* in the Z direction and the opening **12***a* of the second flow path **12** is formed in both surfaces **1***b* on a Y direction side perpendicular to the surface **1***a*. The opening **11***a* is formed in a portion of the surface **1***a* excluding the second flow path **12**. The opening **12***a* is formed in a portion of the surface **1***b* excluding the first flow path **11**.

The fan **2** is configured to make air flow into the first flow path **11** under the control of the control unit **3**. The fan **2** is configured to make air flow into the first flow path **11** from the opening **11***a* on the Z2 direction side. The fan **2** is provided in a state of being in contact with the surface **1***a* on the Z2 direction side to close the opening **11***a* on the Z2 direction side. The fan **2** includes, for example, a blower that blows air into the first flow path **11**.

The control unit **3** is configured to perform control for switching between a first mode where the heat exchange of the heat exchange target is performed by forcing air to flow into the first flow path **11** with the fan **2** and a second mode where the heat exchange of the heat exchange target is performed by natural convection. The control unit **3** is configured to acquire a temperature difference between air and the heat exchange target based on a temperature of air acquired by the first temperature sensor **4** and a temperature of the heat exchange target acquired by the second temperature sensor **5**. In the present embodiment, the first flow path **11** is configured to be used in both the first mode and the second mode. The control unit **3** includes, for example, a central processing unit (CPU), a read only memory (ROM), and a random access memory (RAM).

The first temperature sensor **4** is configured to acquire the temperature of air. The first temperature sensor **4** is provided in the vicinity of the opening **11***a* on the Z2 direction side and acquires the temperature of air flowing into the first flow path **11**. The first temperature sensor **4** is configured to output the acquired temperature of air to the control unit **3**.

The second temperature sensor **5** is configured to acquire the temperature of the heat exchange target. The second temperature sensor **5** is provided in the vicinity of the opening **12***a* on the Y1 direction side and acquires the temperature of the heat exchange target flowing into the second flow path **12**. The second temperature sensor **5** is configured to output the acquired temperature of the heat exchange target to the control unit **3**.

(Configuration of First Flow Path)

Next, the configuration of the first flow path **11** will be described with reference to FIG. **2**. As shown in FIG. **2**, the first flow path **11** is formed by the separate plate **10** and one first corrugated fin **13**. In an example of FIG. **2**, for convenience, the separate plate **10** on an X1 direction side is not shown.

As shown in FIG. **2**, the separate plate **10** extends along a YZ plane. In the example shown in FIG. **2**, the separate plate **10** has long sides disposed in an orientation along the Z direction. The first corrugated fin **13** includes a plurality of fin portions **13***a*, a first connecting portion **13***b*, and a second connecting portion **13***c*. The plurality of fin portions **13***a* are provided to extend upward from the separate plate **10**. The plurality of fin portions **13***a* are provided to extend upward from the separate plate **10** from an X2 direction side toward the X1 direction side. The plurality of fin portions **13***a* are connected by the first connecting portion **13***b* on the X1 direction side. The plurality of fin portions **13***a* are connected by the second connecting portion **13***c* on the X2 direction side. The first connecting portion **13***b* and the second connecting portion **13***c* are alternately provided in the Y direction. The first flow path **11** is divided by the plurality of fin portions **13***a* provided to extend upward from the separate plate **10**.

As shown in FIG. **2**, the plurality of fin portions **13***a* are disposed in parallel at predetermined intervals **p1** in the width direction (Y direction) of the first flow path **11**. The plurality of fin portions **13***a* are formed to have an undulating shape from one end **11***b* toward the other end **11***c* of the first flow path **11** in the width direction (Y direction) of the first flow path **11**. Specifically, the plurality of fin portions **13***a* are disposed at the intervals **p1** and at equal intervals over the whole width in the width direction (Y direction) of the first flow path **11**. The interval **p1** of the plurality of fin portions **13***a* is a distance of a gap portion of the fin portions **13***a* excluding a plate thickness. The undulating shape is a shape in which a crest portion **11***d* and a trough portion **11***e* are alternately repeated in a direction (Z direction) from one end **11***b* toward the other end **11***c* of the first flow path **11**.

In the present embodiment, the plurality of fin portions **13***a* undulate in a period **p2**. The period **p2** is a distance between the crest portions **11***d* on the Y1 direction side of the fin portion **13***a* in the Z direction.

As shown in FIG. **3**, the plurality of fin portions **13***a* undulate such that an undulating pattern of the same waveform is repeated at a fixed undulation width W in the width direction (Y direction) of the first flow path **11**. The undulation width W is a distance between the crest portion **11***d* on the Y1 direction side of the fin portion **13***a* and the trough portion **11***e* on the Y1 direction side of the fin portion **13***a*. The undulating pattern means a unit of repetition in the Z direction in a case where the plurality of fin portions **13***a* undulate.

In the present embodiment, since the undulation width W is fixed, the distance between a trough portion **11***g* on the Y2 direction side of the fin portion **13***a* and a crest portion **11***f* on the Y2 direction side of the fin portion **13***a* is equal to the distance between the crest portion **11***d* on the Y1 direction side of the fin portion **13***a* and the trough portion **11***e* on the Y1 direction side of the fin portion **13***a*.

FIG. **4** is a schematic view as the first flow path **11** is viewed from the Z1 direction side. FIG. **4** shows the fin portions **13***a*, the first connecting portion **13***b*, the second connecting portions **13***c*, a surface **110***a* in the crest portion **11***d* (see FIG. **3**) of the fin portion **13***a* that is visible from the Z2 direction side, a surface **110***b* in the trough portion **11***e* (see FIG. **3**) of the fin portion **13***a* that is visible from the Z2 direction side, a surface **110***c* in the crest portion **11***f* (see FIG. **3**) of the fin portion **13***a* that is visible from the Z2 direction side, and a surface **110***d* in the trough portion **11***g* (see FIG. **3**) of the fin portion **13***a* that is visible from the Z2 direction side. FIG. **4** is not a sectional view, and the separate plate **10**, the fin portions **13***a*, the first connecting portion **13***b*, the second connecting portions **13***c*, and the surface **110***a* to the surface **110***d* are hatched differently for ease of identification.

As shown in FIG. **4**, the plurality of fin portions **13***a* undulate periodically such that the other end **11***c* of the first flow path **11** is visible as viewed from one end **11***b* of the first flow path **11**. Specifically, the undulation width W is at least a size less than a half of the interval **p1** of the plurality of fin portions **13***a*. In other words, the plurality of fin portions **13***a* undulate such that a distance D between an end portion **111***a* on the Y2 direction side of the surface **110***b* and an end portion **111***b* on the Y1 direction side of the surface **110***c* is not 0 (zero). That is, the plurality of fin portions **13***a* undulate such that a size obtained by adding a width **W1** in the Y direction of the surface **110***b* and a width **W2** in the Y direction of the surface **110***c* of each of the plurality of fin portions **13***a* is smaller than the interval **p1** of the plurality of fin portions **13***a*. In the present embodiment, the interval **p1** of the plurality of fin portions **13***a* is within a range of equal to or greater than 5 mm and equal to or less than 10 mm. In the present embodiment, the interval **p1** of the plurality of fin portions **13***a* is, for example, about 8 mm. In the present embodiment, a thickness of the first fin portion is about 0.25 mm.

In the present embodiment, in performing the heat exchange of the heat exchange target, the first flow path **11** is used in both forced heat exchange where the heat exchange of the heat exchange target is performed by forcing air to flow into the first flow path **11** and natural heat exchange where the heat exchange of the heat exchange target is performed by natural convection. Hereinafter, it has been confirmed that the heat exchanger **1** according to the present embodiment can be used in both forced heat exchange and natural heat exchange by performing a simulation using the heat exchanger **1** according to the present embodiment and the comparative example. A simulation result described below is obtained by cooling the heat exchange target using the heat exchanger **1** according to the embodiment and a comparative example.

(Simulation Result of Heat Exchange Amount)

A graph **G1** shown in FIG. **5** shows change in heat exchange amount in changing a front face wind velocity using the heat exchanger **1** in the present embodiment and a heat exchanger according to the comparative example. The graph **G1** takes a heat exchange amount (kW: kilowatt) as the vertical axis and takes a front face wind velocity (m/s: millimeters per second) as the horizontal axis. The front face wind velocity is a wind velocity of air in the opening **11***a* in flowing into the heat exchanger **1**, and is not a wind velocity of air that flows among the plurality of fin portions **13***a*. The simulation result shown in the graph **G1** is a result obtained by performing a simulation in a state where a temperature of air in the opening **11***a* in flowing into the first flow path **11** is fixed at 30 degrees, and a temperature of the heat exchange target fluid that flows in the second flow path **12** is fixed at 85 degrees.

In the graph **G1**, as an example, a heat exchanger in which fins having a thickness of about 0.25 mm are disposed at disposition intervals of about 8 mm is used. As a comparative example, a heat exchanger for natural heat exchange that includes fins disposed suitably for natural heat exchange and a heat exchanger for forced heat exchange that includes fins suitable for forced heat exchange are used. The heat exchanger for natural heat exchange is, for example, a heat exchanger in which fins having a thickness of about 0.25 mm are disposed at disposition intervals of about 8 mm. The heat exchanger for forced heat exchange is, for example, a heat exchanger in which fins having a thickness of about 0.25 mm are disposed at disposition intervals of about 3.4 mm. Both the fins of the heat exchanger for natural heat exchange and the fins of the heat exchanger for forced heat exchange do not have an undulating shape from one end toward the other end of the first flow path in the Y direction. The fins of the heat exchanger for natural heat exchange and the fins of the heat exchanger for forced heat exchange are configured with plain type corrugated fins.

In the graph G**1**, a simulation result of the heat exchanger **1** according to the present embodiment is shown by a solid line **20**. A simulation result of the heat exchanger for natural heat exchange is shown by a broken line **21**. A simulation result of the heat exchanger for forced heat exchange is shown by a one-dot chain line **22**. In the graph G**1**, for convenience, a value of a simulation result by natural heat exchange is shown at a position where the front face wind velocity is 0 (zero).

As shown in the graph G**1**, in a case where the front face wind velocity is 0 (zero), a result shows that the heat exchange amount of the heat exchanger for natural heat exchange is the greatest, and the heat exchange amount of the heat exchanger **1** according to the present embodiment is the second greatest, and the heat exchange amount of the heat exchanger for forced heat exchange is the smallest. A case where the front face wind velocity is 0 (zero) is heat exchange by natural convection. That is, a case where the front face wind velocity is 0 (zero) is heat exchange by the second mode. A case where the front face wind velocity is equal to or higher than 0 (zero) is heat exchange by the first mode.

As shown in the graph G**1**, in a case where the front face wind velocity increases to 0.5 (m/s), the heat exchange amount of the heat exchanger for forced heat exchange is the greatest, and the heat exchange amount of the heat exchanger for natural heat exchange is the smallest. In a range of the front face wind velocity of 0.5 (m/s) to 2.0 (m/s), the heat exchange amount of the heat exchanger for forced heat exchange is the greatest, and the heat exchange amount of the heat exchanger for natural heat exchange is the smallest. In a case where the front face wind velocity increases higher than 2.0 (m/s), the heat exchange amount of the heat exchanger **1** according to the present embodiment is the greatest, and the heat exchange amount of the heat exchanger for natural heat exchange is the smallest. Specifically, in a case where the front face wind velocity is 2.0 (m/s), a ratio of the heat exchange amount of the heat exchanger **1** according to the present embodiment to the heat exchange amount of the heat exchanger for forced heat exchange is about 96%. A ratio of the heat exchange amount of the heat exchanger for natural heat exchange to the heat exchange amount of the heat exchanger for forced heat exchange is about 39%. In a case where the front face wind velocity is 3.0 (m/s), a ratio of the heat exchange amount of the heat exchanger **1** according to the present embodiment to the heat exchange amount of the heat exchanger for forced heat exchange is about 112%. A ratio of the heat exchange amount of the heat exchanger for natural heat exchange to the heat exchange amount of the heat exchanger for forced heat exchange is about 40%. That is, it has been confirmed that the heat exchanger **1** according to the present embodiment has heat exchange efficiency equal to or higher than the heat exchanger for forced heat exchange in the heat exchange by the first mode.

With the heat exchanger **1** according to the present embodiment, in the heat exchange by the second mode, a ratio of the heat exchange amount of the heat exchanger **1** according to the present embodiment to the heat exchange amount of the heat exchanger for natural heat exchange is about 93%. A ratio of the heat exchange amount of the heat exchanger for forced heat exchange to the heat exchange amount of the heat exchanger for natural heat exchange is about 39%. That is, it has been confirmed that the heat exchanger **1** according to the present embodiment has heat exchange efficiency equal to the heat exchanger for natural heat exchange in the heat exchange by the second mode. With this, it has been confirmed that the heat exchanger **1** according to the present embodiment can be used in both the first mode and the second mode.

(Simulation Result of Pressure Loss)

A graph G**2** shown in FIG. **6** shows change in pressure loss in changing the front face wind velocity using the heat exchanger **1** in the present embodiment and the heat exchanger according to the comparative example. The graph G**2** takes a pressure loss (Pa: pascal) as the vertical axis and takes a front face wind velocity (m/s: millimeters per second) as the horizontal axis. In the graph G**2**, a simulation is performed using the heat exchanger **1** according to the present embodiment, the heat exchanger for natural heat exchange, and the heat exchanger for forced heat exchange.

In the graph G**2**, a simulation result of the heat exchanger **1** according to the present embodiment is shown by a solid line **23**. A simulation result of the heat exchanger for natural heat exchange is shown by a broken line **24**. A simulation result of the heat exchanger for forced heat exchange is shown by a one-dot chain line **25**. In the graph G**2**, for convenience, a value of the simulation result by natural heat exchange is shown at a position where the front face wind velocity is 0 (zero).

As shown in the graph G**2**, in a case where the front face wind velocity is 0 (zero), in all heat exchangers, the pressure loss is 0 (zero). In a range of the front face wind velocity to 1.5 (m/s), a result shows that the pressure loss of the heat exchanger for forced heat exchange is the greatest, and the pressure loss of the heat exchanger for natural heat exchange is the smallest. In a range of the front face wind velocity higher than 1.5 (m/s), a result shows that the pressure loss of the heat exchanger **1** according to the present embodiment is the greatest, and the heat exchange amount of the heat exchanger for natural heat exchange is the smallest. From the results, it has been confirmed that, in a case where the front face wind velocity is high, since the pressure loss is increased, and the heat exchange efficiency is also increased, the heat exchanger **1** according to the present embodiment can be used in the heat exchange by the first mode. In the heat exchanger **1** according to the present embodiment, although the disposition interval of the fins is greater than the fins of the heat exchanger for forced heat exchange, it is considered that the pressure loss greater than the fins of the heat exchanger for forced heat exchange is generated in the vicinity of 1.5 (m/s) since forming of turbulence with an increase in wind velocity is promoted by the undulating shape of the first fin portion. It has been confirmed that, in a case where the front face wind velocity is low, since the pressure loss is small like the heat exchanger for natural heat exchange, the heat exchanger **1** according to the present embodiment can be used in the heat exchange by the second mode. With this, it has been confirmed that the heat exchanger **1** according to the present embodiment can be used in both the first mode and the second mode.

(Switching Between First Mode and Second Mode)

In the present embodiment, the control unit **3** is configured to switch between the first mode and the second mode based on the temperature of the heat exchange target.

Specifically, the control unit **3** forces air to flow into the first flow path **11** with the fan **2** such that the temperature of the heat exchange target fluid flowing into the second flow path **12** acquired by the second temperature sensor **5** is equal to or lower than a predetermined temperature. In the present embodiment, the control unit **3** acquires a difference between the temperature of air flowing into the first flow path **11** acquired by the first temperature sensor **4** and the temperature of the heat exchange target fluid flowing into the second flow path **12** acquired by the second temperature sensor **5**. The control unit **3** adjusts an inflow amount of air by the fan **2** based on the acquired temperature difference between air flowing into the first flow path **11** and the heat exchange target fluid flowing into the second flow path **12**. That is, in a case where the temperature difference between air and the heat exchange target is small, the control unit **3** increases the inflow amount of air by the fan **2**. In a case where the temperature difference between air and the heat exchange target is large, the control unit **3** decreases the inflow amount of air by the fan **2**.

The control unit **3** stops the operation of the fan **2** in a case where the acquired temperature difference between air flowing into the first flow path **11** and the heat exchange target fluid flowing into the second flow path **12** is large, and the needed heat exchange amount is decreased. That is, the control unit **3** performs control for performing heat exchange in the second mode. In performing heat exchange in the second mode, the fan **2** is stopped. Accordingly, air passes through the gap of the fan **2** by natural convection, and flows into the first flow path **11** from the opening **11***a* on the Z2 direction side.

Next, processing in which the control unit **3** according to the present embodiment switches between the first mode and the second mode will be described with reference to FIG. **7**.

In Step S**1**, the control unit **3** determines whether or not an operation input to start automatic switching between natural heat exchange and forced heat exchange is performed. In a case where the operation input to start automatic switching is performed, the process proceeds to Step S**2**. In a case where the operation input to start automatic switching is not performed, the processing of Step S**1** is repeated.

In Step S**2**, the control unit **3** acquires the temperature of the heat exchange target fluid flowing into the second flow path **12**. Specifically, the control unit **3** acquires the temperature of the heat exchange target fluid flowing into the second flow path **12** with the second temperature sensor **5** (see FIG. **1**).

In Step S**3**, the control unit **3** determines whether or not the temperature of the heat exchange target fluid is equal to or higher than the predetermined temperature. In a case where the temperature of the heat exchange target fluid is equal to or higher than the predetermined temperature, the process proceeds to Step S**4**. In a case where the temperature of the heat exchange target fluid is lower than the predetermined temperature, the process proceeds to Step S**5**.

In Step S**4**, the control unit **3** performs switching to the second mode. Specifically, the control unit **3** performs switching to the second mode by stopping the fan **2**. In a case where the fan **2** is stopped, the processing of Step S**4** is omitted. That is, in a case where the operation is performed in the second mode, the processing of Step S**4** is omitted.

In a case where the process proceeds from Step S**3** to Step S**5**, in Step S**5**, the control unit **3** performs switching to the first mode. Specifically, the control unit **3** performs switching to the first mode by operating the fan **2**. The control unit **3** may control the amount of air flowing into the first flow path **11** with the fan **2** based on the temperature of air acquired by the first temperature sensor **4**. In a case where the fan **2** is being operated, the processing of Step S**5** is omitted.

In Step S**6**, the control unit **3** determines whether or not an operation input to end automatic switching is performed. In a case where the operation input to end automatic switching is not performed, the process proceeds to Step S**2**. In a case where the operation input to end automatic switching is performed, the process ends.

Effects of First Embodiment

In the first embodiment, the following effects can be obtained.

In the first embodiment, as described above, the plurality of fin portions **13***a* are disposed in parallel at the predetermined intervals p**1** in the width direction (Y direction) of the first flow path **11** through which air flows, and are formed to have the undulating shape from one end **11***b* toward the other end **11***c* of the first flow path **11** in the width direction of the first flow path **11**, the first flow path **11** is configured to be used in both the first mode where heat exchange is performed by forcing air to flow in and the second mode where heat exchange is performed by natural convection. Thus, since the first flow path **11** is used in both the first mode and the second mode, it is possible to restrain the structure of the heat exchanger **1** from being complicated, compared to a configuration in which both flow paths of a flow path for a first mode and a flow path for a second mode are provided. Since the plurality of fin portions **13***a* have the undulating shape in the width direction (Y direction) of the first flow path **11**, it is possible to promote heat transfer with turbulence of flown-in air, compared to a configuration in which the plurality of fin portions **13***a* do not have the undulating shape. It is also possible to increase a heat transfer area. As a result, it is possible to switch between performing heat exchange by natural convection and heat exchange by forcing air to flow in, and to restrain the structure of the heat exchanger **1** from being complicated.

Since the plurality of fin portions **13***a* are provided continuously from one end **11***b* to the other end **11***c* of the first flow path **11**, and undulate periodically such that the other end of the first flow path **11** is visible as viewed from one end **11***b* of the first flow path **11**, a through flow path is formed in the first flow path **11**. Accordingly, it is possible to suppress an increase in pressure loss of air flowing in the first flow path **11**, compared to a configuration in which a through flow path is not formed in the first flow path **11** with the plurality of fin portions **13***a*. As a result, even in a case where the plurality of fin portions **13***a* have the undulating shape, it is possible to secure heat exchange efficiency in the second mode where heat exchange is performed by natural convection.

The plurality of fin portions **13***a* undulate such that the undulating pattern having the same waveform is repeated at the fixed undulation width W in the width direction (Y direction) of the first flow path **11**, and the undulation width W is at least a size less than a half of the interval p**1** of the plurality of fin portions **13***a*. Thus, the plurality of fin portions **13***a* undulate such that the undulating pattern having the same waveform is repeated at the fixed undulation width W in the width direction (Y direction) of the first flow path **11**. For this reason, it is possible to simplify the structure (shape) of the plurality of fin portions **13***a*, compared to a configuration in which the undulation width W and/or the undulating pattern of the plurality of fin portions

13*a* is different halfway. The undulation width W of the plurality of fin portions **13***a* is at least the size less than a half of the disposition interval **p1** of the plurality of fin portions **13***a*. Thus, it is possible to make a configuration in which the other end **11***c* of the first flow path **11** is visible as viewed from one end **11***b* of the first flow path **11**, and to secure heat exchange efficiency in the second mode. As a result, it is possible to achieve simplification of the structure (shape) of the plurality of fin portions **13***a* and securing of heat exchange efficiency in the second mode.

Since the interval **p1** of the plurality of fin portions **13***a* is within a range of equal to or greater than 5 mm and equal to or less than 10 mm, it is possible to dispose the plurality of fin portions **13***a* at intervals suitable for the second mode where heat exchange is performed by natural convection. In a case where the disposition interval of the plurality of fin portions **13***a* is set within the range, while high performance is obtained in the second mode where heat exchange is performed by natural convection of air, the disposition interval is large for the first mode where heat exchange is performed by forcing air to flow in. That is, in a case where the plurality of fin portions **13***a* are disposed at the disposition interval within the range of equal to or greater than 5 mm and equal to or less than 10 mm, heat exchange performance by the first mode is degraded. Accordingly, as shown in the above-described example, it has been confirmed that the plurality of fin portions **13***a* have the undulating shape, whereby it is possible to secure high performance even in heat exchange by the first mode even in a case where the plurality of fin portions **13***a* are disposed at the disposition interval within the range of equal to or greater than 5 mm and equal to or less than 10 mm.

The plurality of fin portions **13***a* are disposed at the equal intervals over the whole width in the width direction (Y direction) of the first flow path **11**. Thus, it is possible to perform heat exchange by the first mode and heat exchange by the second mode using the whole first flow path **11**, unlike a configuration in which a part where heat exchange is performed by the first mode and a part where heat exchange is performed by the second mode are formed by changing the interval **p1** of the plurality of fin portions **13***a* halfway of the first flow path **11**. As a result, it is possible to suppress degradation of heat exchange efficiency of each heat exchange mode.

Since the control unit **3** is configured to switch between the first mode and the second mode based on the temperature of the heat exchange target, the first mode and the second mode are switched based on the temperature of the heat exchange target. Accordingly, it is possible to suppress an increase in power consumption, for example, compared to a configuration in which heat exchange is constantly performed by the first mode. It is also possible to efficiently perform the heat exchange of the heat exchange target, for example, compared to a configuration in which heat exchange is constantly performed by the second heat exchange mode. As a result, it is possible to efficiently perform the heat exchange of the heat exchange target while suppressing an increase in power consumption.

The heat exchange target includes the heat exchange target fluid, and the heat exchanger **1** further includes the second flow path **12** through which the heat exchange target fluid flows in a state of being in contact with the separate plate **10** on which the plurality of fin portions **13***a* are provided. Thus, it is possible to easily bring the separate plate **10** on which the plurality of fin portions **13***a* are provided, and the heat exchange target fluid into contact with each other by making the heat exchange target fluid flow into the second flow path **12**, and to easily perform the heat exchange of the heat exchange target fluid.

In a fin structure of the heat exchanger **1**, the plurality of fin portions **13***a* are disposed in parallel at the predetermined intervals **p1** in the width direction (Y direction) of the first flow path **11** through which air flows, and are formed to have the undulating shape from one end **11***b* toward the other end **11***c* of the first flow path **11** in the width direction of the first flow path **11**, and in performing the heat exchange of the heat exchange target, the first flow path **11** is configured to be used in both forced heat exchange where the heat exchange of the heat exchange target is performed by forcing air to flow into the first flow path **11** and natural heat exchange where the heat exchange of the heat exchange target is performed by natural convection. Thus, it is possible to provide the fin structure of the heat exchanger **1** capable of switching between performing heat exchange by natural convection and heat exchange by forcing air to flow in, and restraining the structure of the heat exchanger **1** from being complicated, like the above-described heat exchange system **100**. In the fin structure of the heat exchanger **1**, the plurality of fin portions **13***a* are disposed at the equal intervals over the whole width in the width direction (Y direction) of the first flow path **11**. Thus, it is possible to perform heat exchange by the first mode and heat exchange by the second mode using the whole first flow path **11**, unlike a configuration in which a part where heat exchange is performed by the first mode and a part where heat exchange is performed by the second mode are formed by changing the disposition interval **p1** of the plurality of fin portions **13***a* halfway of the first flow path **11**. As a result, it is possible to suppress degradation of heat exchange efficiency of each heat exchange mode.

In the fin structure of the heat exchanger **1**, since the plurality of fin portions **13***a* are provided continuously from one end **11***b* to the other end **11***c* of the first flow path **11**, and undulate periodically such that the other end of the first flow path **11** is visible as viewed from one end **11***b* of the first flow path **11**, a through flow path is formed in the first flow path **11**. Accordingly, it is possible to suppress an increase in pressure loss of air flowing in the first flow path **11**, compared to a configuration in which a through flow path is not formed in the first flow path **11** with the plurality of fin portions **13***a*. As a result, even in a case where the plurality of fin portions **13***a* have the undulating shape, it is possible to secure heat exchange efficiency in the second mode where heat exchange is performed by natural convection.

Second Embodiment

Next, an angle range of a maximum inclination angle θ (see FIG. **8**) of a connecting portion **11***h* (see FIG. **8**) of each of a plurality of fin portions **131** (see FIG. **8**) of a first corrugated fin **130** (see FIG. **8**) according to a second embodiment will be described with reference to FIGS. **8** to **11**. The same configurations as in the above-described first embodiment are represented by the same reference signs, and detailed description thereof will not be repeated.

The plurality of fin portions **131** according to the second embodiment have the same configuration as the plurality of fin portions **13***a* according to the above-described first embodiment, except for a case where the maximum inclination angle θ is different. As shown in FIG. **8**, the plurality of fin portions **131** undulate such that an undulating pattern having the same waveform is repeated at a fixed undulation width W in the width direction (Y direction) of the first flow path **11**. The undulating pattern includes a crest portion **11***d* that protrudes to one side (Y1 direction side) in the width direction of the first flow path **11**, a trough portion **11***e* that protrudes to the other side (Y2 direction side), and a connecting portion **11***h* that connects the crest portion **11***d* and the trough portion **11***e*. In the present embodiment, the maximum inclination angle θ of the connecting portion **11***h* with respect to a direction (Z direction) from one end **11***b* side toward the other end **11***c* side of the first flow path **11** falls within an angle range of equal to or greater than 10 degrees and equal to or less than 30 degrees. An example shown in FIG. **8** is a case where the maximum inclination angle θ is 20 degrees.

In the example shown in FIG. **8**, although each of the crest portion **11***d* and the trough portion **11***e* has a shape extending along a direction (Z direction) in which the first flow path **11** extends, the crest portion **11***d* and the trough portion **11***e* may not extend along the direction (Z direction) in which the first flow path **11** extends. That is, the connecting portions **11***h* may be continuously connected to form an undulating pattern. In this case, out of contacts between the connecting portions **11***h*, a contact that protrudes to one side (Y1 direction side) may be referred to as a crest portion, and a contact that protrudes to the other side (Y2 direction side) may be referred to as a trough portion.

A period p**2** of undulation is determined by the disposition interval p**1** of the fin portions **131** and the maximum inclination angle θ of the connecting portion **11***h*. In the second embodiment, the heat exchanger **1** is used in both the first mode and the second mode. Accordingly, the period p**2** of undulation is set to a range based on a range of the disposition interval p**1** of the fin portions **131**, a range of the maximum inclination angle θ of the connecting portion **11***h*, and a heat discharge amount capable of using both the first mode and the second mode. Specifically, a lower limit value of the period p**2** of undulation is 0.5 times of the disposition interval p**1** of the fin portions **131**. An upper limit value of the period p**2** of undulation is a value in a case where the first flow path **11** is configured such that the other end **11***c* of the first flow path **11** is visible as viewed from one end **11***b* of the first flow path **11** in a case where the disposition interval p**1** of the fin portions **131** is set to a range of equal to or greater than 5 mm and equal to or less than 10 mm, and the maximum inclination angle θ of the connecting portion **11***h* is set to be equal to or greater than 10 degrees and equal to or less than 30 degrees.

Next, simulation results of a heat exchange amount and a pressure loss in a case where the maximum inclination angle θ of the connecting portion **11***h* and the period p**2** of undulation are changed will be described with reference to FIGS. **9** to **11**. Simulation results described below are results using a first corrugated fin **130** in which the maximum inclination angle θ of the connecting portion **11***h* in the heat exchanger **1** is set to 20 degrees, 10 degrees, and 30 degrees, the first corrugated fin **130** in which the maximum inclination angle θ of the connecting portion **11***h* is 20 degrees, and a period p**3** of undulation is a half of the period p**2** of undulation, and a first corrugated fin **130** in which a period p**4** of undulation is two times of the period p**2** of undulation, as shown in FIG. **9**. The simulation results described below also include a result using a first corrugated fin **140** in which the maximum inclination angle θ of the connecting portion **11***h* is 0 degrees (a so-called plain fin), as a comparative example. As shown in FIG. **9**(F), the first corrugated fin **140** according to the comparative example has a shape with no undulation in a fin portion.

As shown in FIG. **9**(A), in a first corrugated fin **130***a*, connecting portion **11***h* is disposed such that the maximum inclination angle θ of the connecting portion **11***h* is 20 degrees. As shown in FIG. **9**(B), in a first corrugated fin **130***b*, the connecting portion **11***h* is disposed such that the maximum inclination angle θ of the connecting portion **11***h* is 10 degrees. As shown in FIG. **9**(C), in a first corrugated fin **130***c*, the connecting portion **11***h* is disposed such that the maximum inclination angle θ of the connecting portion **11***h* is 30 degrees. As shown in FIGS. **9**(A) to **9**(C), the period of undulation of the first corrugated fin **130***a* to the first corrugated fin **130***c* is the period p**2**.

As shown in FIG. **9**(D), a first corrugated fin **130***d* is configured such that the maximum inclination angle θ of the connecting portion **11***h* is 20 degrees, and the period p**4** of undulation is a half of the period p**2** of undulation. As shown in FIG. **9**(E), a first corrugated fin **130***e* is configured such that the maximum inclination angle θ of the connecting portion **11***h* is 20 degrees, and the period p**4** of undulation is two times of the period p**2** of undulation.

(Simulation Result of Heat Exchange Amount to Maximum Inclination Angle of Connecting Portion and Period of Undulation)

A graph G**3** shown in FIG. **10** takes a heat exchange amount as the vertical axis and takes a front face wind velocity as the horizontal axis. In the graph G**3**, a simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 10 degrees is shown by a one-dot chain line **30**. In the graph G3, a simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 20 degrees is shown by a solid line **31**. In the graph G3, a simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 30 degrees is shown by a broken line **32**. In the graph G3, a simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 20 degrees, and the period p**3** of undulation is a half of the period p**2** of undulation is shown by a two-dot chain line **33**. In the graph G**3**, a simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 20 degrees, and the period p**4** of undulation is two times of the period p**2** of undulation is shown by a bold line **34**. In the graph G**3**, a simulation result according to the comparative example is shown by a bold dotted line **35**. In the graph G3, a case where the front face wind velocity is 0 (zero) means heat exchange by the second mode. In the graph G**3**, a case where the front face wind velocity is equal to or higher than 0 (zero) means heat exchange by the first mode.

As shown in the graph G**3**, in a case of the second mode, all simulation results in a case where the maximum inclination angle θ of the connecting portion **11***h* is 10 degrees, 20 degrees, and 30 degrees show the substantially same heat exchange amount as the simulation result according to the comparative example.

As shown in the graph G**3**, in a case of heat exchange by the first mode, the simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 10 degrees shows that the heat exchange amount is increased with respect to the simulation result according to the comparative example. Specifically, in the first mode, the simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 10 degrees shows that the heat exchange amount is about 1.4 times on average with respect to the simulation result according to the comparative example.

As shown in the graph G**3**, the simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 20 degrees shows that, in a case of the first mode, the heat exchange amount is about 1.7 times on average with respect to the simulation result according to the comparative example.

As shown in the graph G3, the simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 30 degrees shows that, in a case of the first mode, the heat exchange amount is about 2.0 times on average with respect to the simulation result according to the comparative example.

As shown in the graph G3, in a case of the first mode, it has been confirmed that, as the maximum inclination angle θ of the connecting portion **11***h* is increased, the heat exchange amount is increased.

As shown in the graph G3, in a case of the second mode, both the simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 20 degrees, and the period p**3** of undulation is a half of the period p**2** of undulation and the simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 20 degrees, and the period p**3** of undulation is a half of the period p**2** of undulation show the substantially same heat exchange amount as the simulation result according to the comparative example.

As shown in the graph G3, in a case of the first mode, the simulation result in a case where the period p**3** of undulation is a half of the period p**2** of undulation show that the heat exchange amount is increased with respect to the simulation result according to the comparative example. Specifically, the simulation result in a case where the period p**3** of undulation is a half of the period p**2** of undulation shows that, in a case of the first mode, the heat exchange amount is about 1.4 times on average compared to the simulation result according to the comparative example.

As shown in the graph G3, in a case of the first mode, the simulation result in a case where the period p**4** of undulation is two times of the period p**2** of undulation shows that the heat exchange amount is increased compared to the simulation result according to the comparative example. Specifically, the simulation result in a case where the period p**4** of undulation is two times of the period p**2** of undulation shows that, in a case of the first mode, the heat exchange amount is about 1.7 times on average compared to the simulation result according to the comparative example.

As shown in the graph G3, in comparing the simulation result of the period p**4** of undulation with the simulation result of the period p**3** of undulation, in regard to the heat exchange amount in a case of the first mode, the simulation result of the period p**4** of undulation shows the heat exchange amount equal to or greater than the simulation result of the period p**3** of undulation.

With the above, it has been confirmed that, in a case where the maximum inclination angle θ of the connecting portion **11***h* is equal to or greater than 10 degrees and equal to or less than 30 degrees, the heat exchange amount is large compared to the comparative example. It has been confirmed that, in a range of the maximum inclination angle θ of the connecting portion **11***h* of 10 degrees to 30 degrees, as the angle is increased, the heat exchange amount is increased. It has been confirmed that an influence of the period p**2** of undulation on the heat exchange amount is less than an influence of the maximum inclination angle θ of the connecting portion **11***h* on the heat exchange amount.

(Simulation Result of Pressure Loss to Maximum Inclination Angle of Connecting Portion and Period of Undulation)

A graph G4 shown in FIG. **11** takes a pressure loss as the vertical axis and takes a front face wind velocity as the horizontal axis. In the graph G**4**, a simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 10 degrees is shown by a one-dot chain line **36**. In the graph G**4**, a simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 20 degrees is shown by a solid line **37**. In the graph G**4**, a simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 30 degrees is shown by a broken line **38**. In the graph G**4**, a simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 20 degrees, and the period p**3** of undulation is a half of the period p**2** of undulation is shown by a two-dot chain line **39**. In the graph G**4**, a simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 20 degrees, and the period p**4** of undulation is two times of the period p**2** of undulation is shown by a bold line **40**. In the graph G**4**, a simulation result according to the comparative example is shown by a bold dotted line **41**. In the graph G**4**, a case where the front face wind velocity is 0 (zero) means heat exchange by the second mode. In the graph G**4**, a case where the front face wind velocity is equal to or higher than 0 (zero) means heat exchange by the first mode.

As shown in the graph G**4**, in a case of the second mode, all simulation results in a case where the maximum inclination angle θ of the connecting portion **11***h* is 10 degrees, 20 degrees, and 30 degrees show the substantially same pressure loss as the simulation result according to the comparative example.

As shown in the graph G**4**, in a case of the first mode, the simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 10 degrees shows the pressure loss is increased compared to the simulation result according to the comparative example. Specifically, the simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 10 degrees shows that, in a case of the first mode, the pressure loss is about 1.6 times on average with respect to the simulation result according to the comparative example.

As shown in the graph G**4**, the simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 20 degrees shows that, in a case of the first mode, the pressure loss is about 2.8 times on average with respect to the simulation result according to the comparative example.

As shown in the graph G**4**, the simulation result in a case where the maximum inclination angle θ of the connecting portion **11***h* is 30 degrees shows that, in a case of the first mode, the pressure loss is about 6.3 times on average with respect to the simulation result according to the comparative example.

As shown in the graph G**4**, in a case of the first mode, it has been confirmed that, as the maximum inclination angle θ of the connecting portion **11***h* is increased, the pressure loss is increased.

As shown in the graph G**4**, in a case of the first mode, the simulation result in a case where the period p**3** of undulation is a half of the period p**2** of undulation shows that the pressure loss is increased compared to the simulation result according to the comparative example. Specifically, the simulation result in a case where the period p**3** of undulation is a half of the period p**2** of undulation shows that, in a case of the first mode, the pressure loss is about 2.2 times compared to the simulation result according to the comparative example.

As shown in the graph G**4**, in a case of the first mode, the simulation result in a case where the period p**4** of undulation is two times of the period p**2** of undulation shows that the pressure loss is increased compared to the simulation result according to the comparative example. Specifically, the simulation result in a case where the period p**4** of undulation is two times of the period p**2** of undulation shows that, in a case of the first mode, the pressure loss is about 2.2 times on average compared to the simulation result according to the comparative example.

As shown in the graph G**4**, in comparing the simulation result of the period p**4** of undulation with the simulation result of the period p**3** of undulation, the pressure loss in a case of the first mode is the substantially same in the simulation result of the period p**4** of undulation and the simulation result of the period p**3** of undulation.

With the above, it has been confirmed that, in a case where the maximum inclination angle θ of the connecting portion **11***h* is equal to or greater than 10 degrees and equal to or less than 30 degrees, the pressure loss is large compared to the comparative example. In a range of the maximum inclination angle θ of the connecting portion **11***h* of 10 degrees to 30 degrees, it has been confirmed that, as the angle is increased, the pressure loss is increased. It has been confirmed that an influence of the period p**2** of undulation on the pressure loss is less than an influence of the maximum inclination angle θ of the connecting portion **11***h* on the pressure loss.

From the graphs G**3** and G**4**, it has been confirmed that, in a case where the maximum inclination angle θ of the connecting portion **11***h* is 10 degrees, while an increasing rate of the heat exchange amount is not large, the efficiency of heat exchange is high, compared to a case where the maximum inclination angle θ of the connecting portion **11***h* is 20 degrees and 30 degrees. In a case where the maximum inclination angle θ of the connecting portion **11***h* is 30 degrees, it has been confirmed that, while the efficiency of heat exchange is not high, the increasing rate of the heat exchange amount is large, compared to a case where the maximum inclination angle θ of the connecting portion **11***h* is 10 degrees and 20 degrees. That is, it has been confirmed that, preferably, the maximum inclination angle θ of the connecting portion **11***h* falls within a range of equal to or greater than 10 degrees and equal to or less than 30 degrees. In a case where the maximum inclination angle θ of the connecting portion **11***h* is 20 degrees, it has been confirmed that the angle can achieve both a heat discharge amount and heat exchange efficiency. Evaluation of the increasing rate of the heat exchange amount and evaluation of the efficiency of heat exchange are performed based on an amount of change in heat exchange amount and an amount of change in pressure loss with respect to a plane fin in a case where the maximum inclination angle θ of the connecting portion **11***h* is changed. The efficiency of heat exchange is a value that is calculated by dividing the heat exchange amount by the pressure loss.

Effects of Second Embodiment

In the second embodiment, the following effects can be obtained.

In the second embodiment, as described above, the plurality of fin portions **131** undulate such that the undulating pattern having the same waveform is repeated at the fixed undulation width W in the width direction (Y direction) of the first flow path **11**. The undulating pattern includes the crest portion **11***d* that protrudes to one side (Y1 direction side) in the width direction of the first flow path **11**, the trough portion **11***e* that protrudes to the other side (Y2 direction side), and the connecting portion **11***h* that connects the crest portion **11***d* and the trough portion **11***e*. The maximum inclination angle θ of the connecting portion **11***h* with respect to the direction (Z direction) from one end **11***b* side toward the other end **11***c* side of the first flow path **11** falls within the angle range of equal to or greater than 10 degrees and equal to or less than 30 degrees.

Here, in a case where the period p**2** of undulation of the first flow path **11** is fixed, as the maximum inclination angle θ of the connecting portion **11***h* is greater, an effect of turbulence in the first flow path **11** is increased, and a heat transfer area can be increased. In a case where the heat transfer area of the first flow path **11** is increased, as shown in FIG. **10**, it is possible to improve heat exchange performance by the first mode where air is forced to flow in. Note that, in a case where the maximum inclination angle θ of the connecting portion **11***h* is large, as shown in FIG. **11**, the pressure loss in the first flow path **11** increases. As shown in FIG. **10**, in a case where the period p**2** of undulation of the first flow path **11** is fixed, as the maximum inclination angle θ of the connecting portion **11***h* is smaller, the effect of turbulence of the first flow path **11** is decreased, and the heat transfer area is decreased. Thus, heat exchange performance by the first mode is degraded. Note that, in a case where the maximum inclination angle θ of the connecting portion **11***h* is small, as shown in FIG. **11**, the pressure loss of the first flow path **11** decreases. Accordingly, the present inventors have conducted studies by a simulation and have confirmed that, in a case where the maximum inclination angle θ of the connecting portion **11***h* falls within the angle range of equal to or greater than 10 degrees and equal to or less than 30 degrees, it is possible to secure high performance in both heat exchange in the first mode and heat exchange in the second mode. In a case where the maximum inclination angle θ of the connecting portion **11***h* is 20 degrees, it has been confirmed that the angle can achieve both a heat discharge amount and heat exchange efficiency.

Other effects of the second embodiment are the same effects as the effects of the above-described first embodiment.

Modification Examples

The embodiment disclosed herein is to be considered merely illustrative and not restrictive in all respects. The scope of the invention is defined not by the description of the above-described embodiments, but by the claims, and is intended to include all changes (modification examples) within the meaning and range equivalent to the claims.

For example, in the above-described first and second embodiments, although an example of a configuration in which the first flow path **11** is formed to extend in the up-down direction (Z direction) has been shown, the invention is not limited thereto. For example, the first flow path **11** may be formed to extend in an oblique direction.

In the above-described first and second embodiments, although an example of a configuration in which the heat exchanger **1** is a plate fin type heat exchanger has been shown, the invention is not limited thereto. For example, the heat exchanger **1** may be a fin and tube type heat exchanger other than a plate fin. Like a heat sink **6** according to a modification example shown in FIG. **12**, the invention may be applied to a heat sink. In the heat sink **6** shown in FIG. **12**, a plurality of fin portions **61***a* are provided to extend upward from a base portion **60**. The base portion **60** is, for example, a metal member having a plate shape. In the heat sink **6**, a space between a plurality of fin portions **61***a* forms a first flow path **61**. In the heat sink **6**, for example, a semiconductor element or the like is a heat exchange target, and the heat exchange of the semiconductor element or the like is performed by bringing the semiconductor element or the like into contact with the base portion **60**. Even in the heat sink **6** according to the modification example, the plurality of fin portions **61***a* are formed to have an undulating shape from one end **11***b* toward the other end **11***c* of the first flow path **11** in the width direction (Y direction) of the first flow path **11** of the plurality of fin portions **61***a*. That is, the first flow path **11** may be divided by a plurality of fins in which an individual first fin portion is provided individually, not by a corrugated fin. In an example shown in FIG. **12**, although the first flow path **11** is formed to extend in the up-down direction (Z direction), the first flow path **11** may be formed to extend in an oblique direction.

In the above-described first and second embodiments, although an example of a configuration in which the first flow path **11** and the second flow path **12** are perpendicular to each other has been shown, the invention is not limited thereto. For example, the first flow path **11** and the second flow path **12** may be configured to face each other or the first flow path **11** and the second flow path **12** may be configured to be in parallel with each other.

In the above-described first and second embodiments, although an example of a configuration in which the first flow path **11** and the second flow path **12** are alternately laminated in the X direction has been shown, the invention is not limited thereto. The first flow path **11** and the second flow path **12** may not be alternately laminated. For example, the first flow path **11**, the first flow path **11**, the second flow path **12**, the first flow path **11**, the first flow path **11**, the second flow path **12**, and the like may be laminated in this order.

In the above-described first and second embodiments, although an example of a configuration in which the plurality of fin portions **13***a* (a plurality of fin portions **131**) are disposed at the equal intervals over the whole width in the width direction (Y direction) of the first flow path **11** has been shown, the invention is not limited thereto. For example, the plurality of fin portions **13***a* (the plurality of fin portions **131**) may not be disposed at equal intervals over the whole width in the Y direction. Note that, in a case where the plurality of fin portions **13***a* (the plurality of fin portions **131**) are not disposed at equal intervals over the whole width in the Y direction, since the structure of the heat exchanger **1** is complicated, it is preferable that the plurality of fin portions **13***a* (the plurality of fin portions **131**) are disposed at equal intervals over the whole width in the Y direction.

In the above-described first and second embodiments, although an example of a configuration in which the plurality of fin portions **13***a* (the plurality of fin portions **131**) undulate at the fixed undulation width W in the width direction (Y direction) of the first flow path **11** has been shown, the invention is not limited thereto. For example, the undulation width W the plurality of fin portions **13***a* (the plurality of fin portions **131**) may not be fixed. Note that, in a case where the undulation width W of the plurality of fin portions **13***a* (the plurality of fin portions **131**) is not fixed, since the structure of the heat exchanger **1** is complicated, it is preferable that the undulation width W of the plurality of fin portions **13***a* (the plurality of fin portions **131**) is fixed.

In the above-described first and second embodiments, although an example of a configuration in which the plurality of fin portions **13***a* (the plurality of fin portions **131**) undulated such that the undulating pattern having the same waveform is repeated has been shown, the invention is not limited thereto. For example, the plurality of fin portions **13***a* (the plurality of fin portions **131**) may have an undulating shape in which undulating patterns having different waveforms are combined. Note that, in a case where the plurality of fin portions **13***a* (the plurality of fin portions **131**) have an undulating shape in which undulating patterns having different waveforms are combined, since the structure of the heat exchanger **1** is complicated, it is preferable that the plurality of fin portions **13***a* (the plurality of fin portions **131**) undulate such that the pattern having the same waveform is repeated.

In the above-described first and second embodiments, although an example of a configuration in which the interval **p1** of the plurality of fin portions **13***a* (the plurality of fin portions **131**) is about 8 mm has been shown, the invention is not limited thereto. The interval **p1** of the plurality of fin portions **13***a* (the plurality of fin portions **131**) may be, for example, about 6 mm or may be about 9 mm. As long as the interval **p1** of the plurality of fin portions **13***a* is within a range of equal to or greater than 5 mm and equal to or less than 10 mm, the interval **p1** of the plurality of fin portions **13***a* (the plurality of fin portions **131**) may have any value.

In the above-described second embodiment, although an example of a configuration in which the fin portion **13***a* is configured such that the crest portion **11***d* and the trough portion **11***e* are connected by the connecting portion **11***h* inclined at a fixed angle has been shown, the invention is not limited thereto. For example, the crest portion **11***d* and the trough portion **11***e* may be connected by a connecting portion in which the angle changes continuously. As an example, the first flow path **11** may be a so-called sine curve shape in top view. In a case where the first flow path **11** has a sine curve shape, a maximum angle of the connecting portion in which the angle continuously changes may fall within an angle range of equal to or greater than 10 degrees and equal to or less than 30 degrees.

In the above-described first and second embodiments, although an example of a configuration in which the control unit **3** switches between the first mode and the second mode based on the temperature difference between air and the heat exchange target has been shown, the invention is not limited thereto. For example, an input reception unit that receives an input of a user may be provided, and the control unit **3** may be configured to switch between the first mode and the second mode based on an input signal of the user.

In the above-described first and second embodiments, although an example of a configuration in which the fan **2** is provided in the opening **11***a* on the Z2 direction side has been shown, the invention is not limited thereto. For example, the fan **2** may be provided in the opening **11***a* on the Z1 direction side. That is, in the first mode, heat exchange may be performed by forcing air to flow in from the Z1 direction side with the fan **2**, and in the second mode, heat exchange may be performed by making air flow in from the Z2 direction side by natural convection. The position where the fan **2** is provided may be any of the opening **11***a* on the Z1 direction side and the opening **11***a* on the Z2 direction side.

In the above-described first and second embodiments, although an example of a configuration in which the fan **2** sends air to the first flow path **11** has been shown, the invention is not limited thereto. For example, the fan **2** may be configured to make air flow into the first flow path **11** by sucking air.

In the above-described first and second embodiments, although an example of a configuration in which the fan **2** is provided in a state of being in contact with the surface **1***a* on the Z2 direction side to cover the opening **11***a* on the Z2 direction side has been shown, the invention is not limited thereto. For example, the fan **2** may not be configured to cover the opening **11***a*. In a case where the fan **2** is not configured to cover the opening **11***a*, the fan **2** may be connected by a duct, a casing, or the like and may be provided at a remote position.

In the above-described first and second embodiments, although an example of a configuration in which cooling of the heat exchange target is performed has been shown, the present application is not limited thereto. For example, the heat exchanger **1** may b configured to perform heating of the heat exchange target.

REFERENCE SIGNS LIST

1, **6**: heat exchanger
2: fan
3: control unit
10: separate plate (base portion)
11, **41**: first flow path
11*d*: crest portion
11*e*: trough portion
11*h*: connecting portion
12: second flow path
13*a*, **61***a*, **131**: a plurality of fin portions
60: base portion
100: heat exchange system
p**1**: disposition interval (disposition interval of a plurality of fin portions)
W: undulation width
θ: maximum inclination angle

The invention claimed is:

1. A heat exchange system comprising:

a heat exchanger comprising a base portion that is contactable with a heat exchange target, and a plurality of fin portions provided to extend upward from the base portion;

wherein the plurality of fin portions form a first flow path through which air flows;

wherein the plurality of fin portions are disposed at a fixed interval over a whole width in a width direction of the first flow path;

wherein the plurality of fin portions are provided continuously from a first end to a second end of the first flow path;

wherein the plurality of fin portions undulate periodically with a fixed width in the width direction of the first flow path;

wherein the fixed width is a size less than a half of the fixed interval; and

wherein the first flow path is configured to be used in both a first mode where heat exchange of the heat exchange target is performed by forcing air to flow into the first flow path and a second mode where the heat exchange of the heat exchange target is performed by natural convection.

2. The heat exchange system according to claim **1**,

wherein a waveform of undulating of the first flow path includes a crest portion that protrudes to a first side, a trough portion that protrudes to a second side, and a connecting portion that connects the crest portion and the trough portion, in the width direction of the first flow path, and

a maximum inclination angle of the connecting portion with respect to a direction from the first side to the second side of the first flow path is within an angle range of equal to or greater than 10 degrees and equal to or less than 30 degrees.

3. The heat exchange system according to claim **1**,

wherein a disposition interval of the plurality of fin portions is within a range of equal to or greater than 5 mm and equal to or less than 10 mm.

4. The heat exchange system according to claim **1**, further comprising a fan that makes air flow into the first flow path; and a controller that performs control for switching between the first mode and the second mode,

wherein the controller is configured to switch between the first mode and the second mode based on a temperature of the heat exchange target.

5. The heat exchange system according to claim **1**,

wherein the heat exchange target includes a heat exchange target fluid, and

the heat exchanger further includes a second flow path through which the heat exchange target fluid flows in a state of being in contact with the base portion.

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